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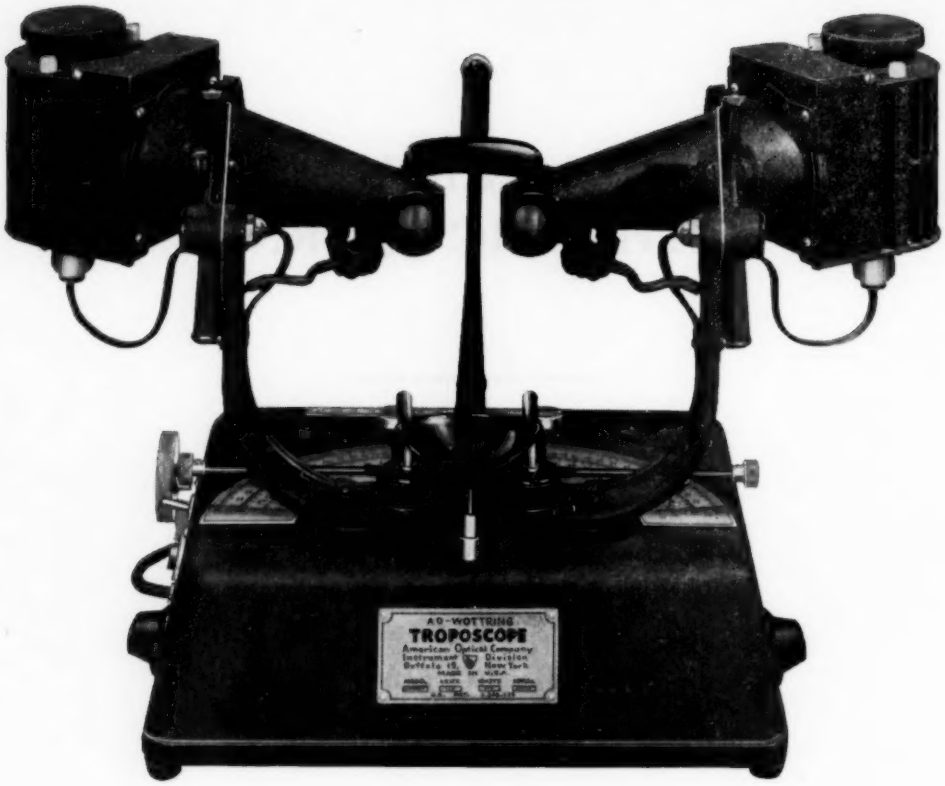

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Symposium: Pleoptics in the Treatment of Strabismus

I

INTRODUCTORY REMARKS

HERMANN M. BURIAN, M.D.
IOWA CITY, IOWA

AMONG the more exciting recent developments in the field of ophthalmology, and more particularly in the field of the neuromuscular anomalies of the eyes, is the development of what has come to be known as *pleoptics* (coined from the Greek *pleon*, meaning full, more, increased). This term refers to the active treatment of functional amblyopia.

It has been evident to all of us who have been engaged in the treatment of amblyopia that occlusion of the fixating eye is not the essence of the treatment, but rather that it is only the negative aspect of the treatment, the positive side of which is to force the patient to use his amblyopic eye. I have for a good many years emphasized this obvious fact, which was, however, often neglected by ophthalmologists and even more by the children's parents, who frequently tend to warn the child not to use the weaker eye. Various kinds of visual tasks have been devised from time to time to aid in the active treatment of amblyopia. We all remember the boon which television brought to us in this respect.

But most exercises were applied more or less haphazardly, and it is a long way from these attempts to the elaborate, carefully planned systems which we know under the names of Bangerter and Cüppers. The methods developed by these two schools, their different theoretical bases, the results achieved with them, and the difficulties arising from their application are still not very well known and understood in this country. This is why the American Orthoptic Council and the American Association of Orthoptic Technicians have chosen to select pleoptics as the topic of tonight's symposium, which is, as it were, the starting gun of pleoptics in the United States. In addition, the work with facilitating drugs, such as strychnine, carried out by the school of Bietti, and some studies done in this country, more particularly in our laboratory at the State University of Iowa and in the St. Louis clinic, will also be discussed.

Pleoptics has been developed with a particular view to the treatment of amblyopia with eccentric fixation. One of the tenets emphasized by those engaged in this work is that one should not occlude the fixating eye in such cases, because it would lead to reinforcement of the extramacular fixation. Certain reservations regarding this viewpoint will be made tonight, at least in one of the discussions. It should, however, not be forgotten that *Chavasse* was the first one to suggest in his forceful way that the eccentrically fixating amblyopic eye should be occluded, rather than the fixating eye. This suggestion

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arose from Chavasse's view that amblyopia was a conditioned reflex—a view with which one may quarrel, as I for one do—but which, nonetheless, marked a turning point in the modern teaching on amblyopia.

This symposium, as our former ones, is a cooperative effort of ophthalmologists and orthoptists. Again as usual, we shall first attempt to set the stage for the clinical discussions by a consideration of the physiopathology of the condition. This will be done by Dr. Gunter von Noorden, who has been collaborating very closely and assiduously with me in our laboratory. We will then hear from Miss Geraldine Wilson of New York, who will present the techniques and methods of pleoptics which she has studied in Switzerland and Germany. Miss Wilson is among the first to apply them in this country. Next, Dr. James E. Miller will speak of his experiences with active amblyopic training and discuss some methods developed in St. Louis. Last, but not least, Miss Nancy Capobianco, who as a former president of the American Association of Orthoptic Technicians needs no introduction, will report to us on her extensive experience with the treatment of amblyopia, acquired in the eye clinic in Rome, Italy, and fortified by prolonged visits both to Professor Cüppers and to Professor Bangerter.

II

PATHOPHYSIOLOGY OF AMBLYOPIA: DIAGNOSTIC AND THERAPEUTIC PRINCIPLES OF PLEOPTICS

GUNTER K. VON NOORDEN
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THE introduction of pleoptics to the armamentarium of those concerned with visual care rejuvenated interest in the nature of strabismic amblyopia and necessitated revision of certain concepts. It was, indeed, true that the development of pleoptic methods and their therapeutic application preceded the discovery of some hitherto unknown characteristics of amblyopia, a development which is by no means unique in the history of medical therapy. The magic fact that *it works* created sufficient curiosity to find out *why*, and in this paper I shall attempt to outline very briefly some of the recent views on amblyopia, followed by a discussion of the diagnostic and therapeutic principles on which pleoptics is based.

PATHOPHYSIOLOGY OF AMBLYOPIA

Strabismic amblyopia is a defect of visual acuity in one eye without visible pathologic changes in the fundus or the refractive media. It occurs in patients with manifest strabismus, or a history of such. In most cases the decrease of visual acuity is reversible if attacked by appropriate means. The impairment is the result of long-lasting active inhibition of the macular function of form vision in the course of an adaptive mechanism, to avoid diplopia or confusion. The various theories regarding the origin and seat of this functional defect were discussed at length before this group three years ago.[7] It may suffice to state that the seat is most likely in the visual cortex, and that the inhibition is selective in nature, inasmuch as certain basic visual functions, such as light sense,[28] flicker fusion frequency,[29] and visual acuity as measured with objective methods[14,22] are less disturbed than the subjectively measured visual acuity, or are entirely normal.

A term frequently used is *amblyopia ex anopsia*, or amblyopia of disuse. This term does not exactly apply to a condition which is the result of active inhibitory impulses. It would appear to be more correct to use this expression in connection with impaired vision due to an uncorrected refractive error, or a high degree of anisometropia. Future investigations will be necessary to show whether inhibitory processes may not also be present in these conditions.

In a third type of amblyopia, none of the aforementioned factors can be held responsible. This type never responds to treatment and differs in several aspects from strabismic amblyopia, as will be pointed out later. Although the fundus appears normal, anatomic damage to the retinal perceptor system or optic pathway must be assumed to be present. The rela-

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tively high incidence of retinal hemorrhages in the newborn is of interest in this connection.[8] Kauffman[15] recently found the occurrence of retinal hemorrhages to be as high as 47 per cent in a group of babies delivered by high-forceps or mid-forceps. No hemorrhages were found in a group of babies delivered by cesarean section. It would appear from these figures that being born by use of high-forceps or mid-forceps is a rather traumatic experience, and a follow-up study in these children would be valuable to ascertain whether, and how frequently, organic amblyopia without evident anatomic macular impairment develops later in life.

In tonight's discussion strabismic amblyopia is the focus of attention, and we shall now analyze some of its characteristics.

Pleoptics has stimulated new interest in an old observation that the amblyopic patient frequently recognizes singly presented optotypes with ease, whereas difficulties arise when the same symbols are presented in a row. Startling discrepancies in measurements of visual acuity are obtained when such a patient is examined with the two methods. Furthermore, it can be observed in the course of pleoptic treatment, that visual acuity improves rapidly if tested with single "E" letters, while the results obtained with the Snellen chart may remain poor. This phenomenon, which is known as "crowding" or "separation difficulty," indicates that the recognition of objects in amblyopia is dependent on their complexity in form. It also leads to the conclusion that there must exist a disturbance of higher cortical functions, similar to agnosia.

In the European literature, single "E" visual acuity is frequently termed "angular" acuity, in contrast to results obtained with the Snellen chart, which are referred to as "cortical" acuity. Recognition is in every case a function of the brain, no matter how simple or complicated the object of recognition may be. We, therefore, object to the misleading contrasting of "angular" and "cortical" acuity, since this would imply that cortical functions are not involved in the recognition of test letters.

Cüppers believes that the "separation difficulty" is created by a form of monocular diplopia or superimposition of letters because of simultaneous localization in two visual directions, arising in the course of therapy of eccentric fixation. This view is supported by his observation that horizontal rows of letters cannot be recognized, while letters in a vertical arrangement and of similar size can still be read. This behavior may hold true in certain cases. However, we were unable to confirm it regularly. Also, this theory does not explain the separation difficulty in patients with central fixation in whom a change of visual directions has not taken place. Investigations with the separation trainer, which was introduced by Bangerter,[2] may throw some light on the nature of crowding. This instrument offers also a promising therapeutic approach to this interesting feature of amblyopia.

As was stated, recent work has shown that functions other than form vision are less disturbed in the amblyopic eye, or may even remain intact under certain conditions. Wald and Burian[28] have demonstrated that the threshold of light recognition is essentially normal in the dark adapted amblyopic eye. Unsteady and jerky fixation is present in amblyopic eyes under conditions of ordinary lighting. This was shown by Mackensen[16,17] with an electro-ophthalmographic method and was confirmed by us.[25]

But we were also able to demonstrate that in many amblyopic eyes complete recovery of the unsteady fixation behavior occurred as soon as these eyes were dark adapted.[25,28] It was also found that no recovery occurred under dark adaptation in patients with organic amblyopia. The extraordinary capacities of the amblyopic eye under scotopic conditions induced us to measure visual acuity with the use of filters[26] and at various levels of illumination.[27] Using a neutral density filter with which the visual acuity of a normal eye was reduced to about one half, only little reduction, no change, or even improvement of visual acuity was noted when the filter was held before the amblyopic eye. However, when the same test was employed in eyes with anatomical damage to the macula, visual acuity was reduced to almost grotesque readings.

The diagnostic importance of these findings is obvious. A determination of the visual acuity at various increasing levels of illumination revealed, furthermore, that the amblyopic eye behaved exactly like the normal control eye at low illuminations. In fact, it showed even relative improvement over the sound eye in several instances.

The scope of this presentation does not permit me to discuss the theoretical implication of these findings. More experimental evidence collected with critical methods is also needed to explain these results sufficiently, and such work is in progress. It may suffice to state that in strabismic amblyopia we are not dealing with a primary affection of the rods and cones, or their immediate synapses. Comparison of the behavior of amblyopic eyes with that of normal eyes leads to the conclusion that the capacity of the amblyopic eye is not at its optimum at photopic levels, and relative improvement of several functions takes place in the dark. Strabismic amblyopia is thus a selective, inhibitory adaptation of the sensory visual system, of which the cones are the peripheral perceptor organ, in the presence of extraocular anomalies. Under conditions in which the function of visual acuity plays a minor role (for example, in the dark), this inhibition becomes pointless and the amblyopic eye resembles the normal eye.

While amblyopic eyes with foveal fixation do not present a great therapeutic problem in younger children, refinement of diagnostic methods and the introduction of pleoptics have greatly stimulated interest in the problem of eccentric fixation. In the past, patients with nonfoveal fixation were usually regarded as not being amenable to treatment. Eccentric fixation is more frequent than one may suspect. Out of 433 cases of amblyopia seen in our orthoptic department within fourteen months, 44 per cent presented nonfoveal fixation. Since many of the cases referred to us in Iowa are complicated and neglected, this represents a biased sample and the number of eccentric fixators in the general amblyopic population is probably considerably lower.

It has been assumed in the past that eccentric fixation is the direct result of poor central vision. In other words, if visual acuity is so low, due to suppression, that it is below that of the peripheral retina, the eye chooses a random point at the margin of the central scotoma which possesses relatively higher resolving power than the macula. This explanation may suffice for certain patients with parafoveal or unsteady fixation. However, it does not explain the persistent use

for fixation of one and the same extrafoveal retinal area, such as can be demonstrated with the star test of the visuscope. The explanation becomes even more improbable if one considers that not infrequently patients persistently use for fixation, retinal areas which are quite remote from the macula and sometimes even nasal to the disc. These are areas which, according to their anatomical structure and physiologic function, have an extremely poor faculty for higher visual functions, certainly worse than areas adjacent to the central scotoma. A different explanation had to be produced to clarify this phenomenon. The first I recall finds its roots in a publication by Bielschowsky,[3] who reported in 1898 on a patient in whom monocular diplopia occurred in the amblyopic eye with eccentric fixation after enucleation of the good eye. Bielschowsky drew the conclusion that if noncorresponding retinal points are stimulated for a long time, the stimulated area of the deviated eye may acquire a different visual direction which will persist even on monocular stimulation. The latency of the innate visual direction and the possibility of its becoming a competitor with the anomalously acquired visual direction leads to the occurrence of monocular diplopia. Incidentally, this concept was brought forward by Bielschowsky in support of the nativistic school of Hering, in contrast to the empirical school of von Helmholtz, who proposed that spatial localization and binocularity were based on experience rather than being inborn. Bielschowsky's interpretation of the importance of the change in visual direction in amblyopic eyes has apparently been disregarded in the literature. Great merit is due Bangerter and Cüppers for having developed these concepts independently into logical therapeutic approaches for patients with amblyopia and eccentric fixation.

The change of the spatial value of the extrafoveal retinal area used for fixation will cause the patient to localize in the subjective "straight ahead" direction any image falling on this area. In other words, the spatial value "straight ahead," which is normally located in the fovea, is transferred to the extrafoveal retinal area. Cüppers[11] has used the theoretical considerations of Lorente de Nó about the retinocortical point-to-point relationship to explain how this shift may come about. Burian had already used these as a basis for models of stereopsis, anomalous retinal correspondence and binocular triplopia.[5,6,9] Lorente de Nó had stated that since each retinal element, owing to extensive arborization, was connected with a large area of the cortex, a point-to-point projection of the retina in the optic centers would be impossible if the theory of "avalanche conduction" of Cajal and Herrick were correct. Lorente de Nó proposed instead that only a limited number of anatomically possible transmission paths were accessible to afferent impulses, because of the high threshold of the neurons. The role of the central stations would thus consist in concentrating the stimuli in a few conductors rather than in increasing the number of active conductors. Physiologically, therefore, a point-to-point relationship would be possible, provided that the nerve cells had a sufficiently high threshold and were made to discharge only when a large number of their synapses was active. However, under certain conditions of physiologic (stereopsis) or pathologic (strabismic deviation) stimulation, anatomically possible pathways other than the preferential physiologic pathways may become activated as a result of

changes in the threshold at the synapses. Thus a shift in subjective visual directions may come about.

Further experimental support for the theory that eccentric fixation results from a change in visual direction was recently given by Mackensen,[19] who was working with the method of quantitative perimetry, developed by Harms, which permits the measurement of the light sensitivity in various parts of the retina. When this method was employed in monocular amblyopia with eccentric fixation, not only was a scotoma found to be present, as can be expected, in the macular region of the field, but the light threshold was even more increased in the extrafoveal fixation area. This proves that low central vision cannot be the cause for eccentric fixation, because an extrafoveal area with marked functional reduction is preferred over the macula, which, as Mackensen could show, is less inhibited. The point of fixation is dependent not so much on its sensitivity function, but rather on the shift of the subjective visual direction. Another interesting observation made in this study was that the threshold discrimination of light was even more increased during binocular fixation. This finding indicates the presence of inhibitory impulses originating from the use of the leading eye.

Mackensen's observations are in contrast to the one by Wald and Burian that threshold discrimination of light is not reduced in dark-adapted amblyopic eyes,[28] and to our findings regarding the return of certain functions under dark adaptation.[25-27] This discrepancy may well be due to the fact that Mackensen's patients were not fully dark adapted. It would be of great interest to repeat his experiments with thoroughly dark-adapted amblyopic eyes. But Mackensen's observations emphasize that the salient feature in the treatment of amblyopia with eccentric fixation is the recovery of the physiologic subjective visual direction of the fovea, which can be achieved with the afterimage method. Nevertheless, we would point out that the abnormality of localization, as such, cannot be the cause of the loss of central visual acuity. It is rather a result of constant stimulation of an extrafoveal area occurring in an already deviated amblyopic eye.

Eccentric fixation may be related to, but is not identical with, anomalous correspondence. In the latter condition, each eye takes up fixation centrally if tested monocularly. Cüppers[12] suggested a very close relationship between the two conditions. He concluded this from his finding that the angle of anomaly coincided in about 50 per cent of the cases with the angle of eccentricity. He claimed that eccentric fixation occurs, so to speak, as the terminal station in an adaptive process, of which anomalous correspondence is an intermediate step.

In evaluating Cüppers' theory, it must be considered that a change of visual direction is not always present in amblyopic eyes with eccentric fixation. We have seen not infrequently that in eyes with parafoveal or even paramacular fixation there was normal spatial localization when the visuscope star was made to fall on the macula. Other patients have been seen in whom a different retinal area would take up fixation each time the eye was examined. One must assume that in these cases there existed no preference for an extrafoveal point and that varying periscotomatous retinal elements were employed in an attempt to obtain optimum resolving power under the prevailing circumstances.

In view of these findings it might be worthwhile to seek for some mechanism other than the shift in visual directions as the responsible cause for eccentric fixation. It is generally accepted by the European school that motor disturbances occurring in amblyopia are secondary to the sensory anomaly. Then unsteadiness of fixation and the nystagmoid movements of the globe, present in amblyopia but not necessarily proportional to its depth, were shown to improve after visual acuity returned to normal in the course of pleoptic treatment.[18,25] On the other hand, we have observed at Iowa that in a number of cases with eccentric fixation, operative correction of the strabismus resulted in spontaneous normalization of the fixation behavior. Similar results have been reported by Ehrich.[13] In several instances, the visual acuity improved postoperatively. These observations suggest that a motor component may indeed be of considerable influence in the development and abolition of sensory anomalies. With this in mind, we would like to call attention to a possible mechanism which may play a decisive role in the development of eccentric fixation. It would appear that through constant stimulation of a nonfoveal retinal area, the latter may become the zero point of the oculomotor system and thus its point of orientation. This presupposes, of course, a change in the motor values of the retinal elements.

When a peripherally situated retinal area in a normal eye receives a stimulus, a fixation movement occurs which brings the image of the stimulating object on the fovea. The direction and extent of the movement of the globe depends on the position of the stimulated area and its distance from the fovea, which has the retinomotor value "zero." Now the nonfoveal retinal area habitually used in eccentric fixation acquires not only the foveal quality of subjective "straight-ahead" localization, but also the foveal "zero" retinomotor value. This can readily be seen in doing the visuscope star test. The essence of eccentric fixation may, therefore, consist in a change in the retinomotor values rather than in a shift of the spatial values. It remains to be seen whether the change in the motor values occurs as a result of the sensory anomaly, *vice versa*, or whether the two are independent.

DIAGNOSTIC PRINCIPLES IN PLEOPTICS

Two diagnostic steps must be taken before pleoptic treatment can be commenced. First, it must be decided whether the amblyopia is organic or functional in nature. This point is of particular importance if one considers the amount of time spent by the therapist and the financial burden imposed on the patient who undergoes lengthy treatments. In most cases, the history or presence of strabismus, or previous gain and subsequent loss of vision under occlusion treatment, point to the functional nature of amblyopia. In addition to this, we have found in our patients that if single "E" vision is two or more lines better than the Snellen chart results, strabismic amblyopia is usually present. A simple and quick test based on our findings of the extraordinary capacities of the amblyopic eye under reduced light conditions should also be mentioned.[26] If the Snellen chart readings are reduced by three lines or more when a neutral density filter is held before the amblyopic eye, the amblyopia is usually organic in origin. If visual acuity is reduced by only one line, remains the same, or even improves with the filter, strabismic amblyopia may be assumed to be present.

The next step is the determination of the fixation behavior. The conventional method of observing the corneal light reflex on monocular fixation of a light source may be sufficient to indicate grossly whether or not there is central fixation. This test, however, is much too coarse to reveal smaller fixation anomalies, such as parafoveal or paramacular fixation, and may indeed be quite misleading in the presence of a large angle kappa. The instrumentation used for exact determination of fixation will be discussed by other members of this panel. However, I would like to mention a photographic method recently reported by us.[24] It consists of a fixation target incorporated in a fundus camera. While the patient is fixating the target, a picture is taken. This method is quite practical for the follow-up of patients undergoing treatment and for the recording of pleoptic results.

THERAPEUTIC PRINCIPLES IN PLEOPTICS

The details of the treatments will be discussed by others. I shall, therefore, limit myself to a brief historical review of the currently employed methods and to the underlying principles.

Since de Buffon[4] recognized in 1743 that occlusion of the sound eye is an efficacious way to treat amblyopia, hardly any therapeutic progress has been made until recent years. Comberg[10] was the first to experiment with active stimulation of the macula, but his methods, unfortunately, received little recognition. It was the great merit of Bangerter[2] to have introduced pleoptics, i.e., methods by which the macula can be actively stimulated and the disturbed visuomanual relationship trained. He was also the first to issue a strong warning against the still widely practiced method of occluding the sound eye when eccentric fixation is present, because the use of the eccentric retinal area would thus only be reinforced and a peripheral retinal element would certainly not acquire better resolving power.

I cannot but interject here that our experiences are not entirely in agreement with this rigid principle, which has found widest acceptance among our European colleagues. While we agree that Bangerter's demand holds true for the older patient group, we have seen that constant occlusion of the sound eye in children with eccentric fixation who were younger than five years, broke up the faulty fixation behavior. The amblyopic eye began to wander and finally assumed central fixation, with subsequent improvement of visual acuity. It should also be remembered that Swenson's technique of partial occlusion of the amblyopic eye[20] has been successfully employed in a number of cases. The plasticity of the infantile sensory adaptive mechanism explains these results, achieved with conventional methods. A therapeutic trial of occlusion of the sound eye in children under five years of age with eccentric fixation is quite justified, particularly if one realizes that children under six years are rarely, if ever, amenable to pleoptic methods.

Miss Capobianco will report on details of Bangerter's fascinating methods. I shall briefly mention the principles underlying Cüppers' method.

Cüppers, who introduced the afterimage method,[24] established the following requirements to treat nonfoveal fixation successfully:

1. Relocation of the subjective visual direction "straight ahead" from the nonfoveal area back to the fovea.

2. Re-establishment of the physiologic superiority of the macula over the peripheral fixation area.

These requirements can be achieved by fixation of afterimages. These are produced by dazzling the peripheral retina, including the area used for eccentric fixation, while the macula remains protected. The result is first a positive, then a desirable negative afterimage in which the macula is represented by a clear bright spot surrounded by a dark circle. The patient will be aware of the position of his macula in space by directing attention to the center of the afterimage. If faulty localization is present, the afterimage will be first seen peripherally because the macula has temporarily lost its spatial value "straight ahead." Repeated perception of the afterimage, however, will result in the patient becoming aware of two afterimages, one being straight ahead, the other one, as previously seen, in the periphery. Sustained attention directed towards the centrally perceived afterimage will finally make the peripheral afterimage disappear. A change of localization has occurred, the innate, "straight ahead" spatial value of the macula is re-established. On monocular examination the eye will fixate centrally. The intermediate stage of monocular diplopia is based on the same sensory mechanisms as the identical phenomenon which occurs after squint surgery in patients with anomalous correspondence, or as evoked artificially by the Walraven technique for the treatment of anamalous retinal correspondence.

The utilization of afterimages is indeed an ingenious approach.* Afterimages have a great attention value and persist for a considerable length of time after the cessation of the stimulus. This latter characteristic, which makes them independent of eye movements, is particularly important for their application in both diagnostic and therapeutic tests. A further salient feature in their use lies in the fact that they are characterized, psychologically at least, as having the properties of real objects in space. They may prevent optokinetic nystagmus (Viefhues[21]), they follow the laws of perspective and vary in size according to the distance of the surface on which they are viewed. Afterimages, therefore, permit refined fixation exercises by the macula, an area which, under the prevailing circumstances of eccentric fixation with abnormal localization and the presence of an abnormal fixation reflex, is excluded from the fixation act.

According to Cüppers,[11] the scotomization of the peripheral retina also reduces sensitivity in this area to such a degree that the macula temporarily regains its physiologic superiority over the periphery. On the other hand, Aulhorn[1] reported that the reduction of sensitivity in the illuminated retinal area is of short duration and returns to normal long before the afterimage fades away. Reduction of retinal sensitivity in the illuminated area and perception of an afterimage are not entirely simultaneous processes, and it would appear from this, that the therapeutic activity of the afterimages is effective only in the initial period of their perception. Their value as fixation objects, of course, remains and is independent of their effect on the light sensitivity of the retina.

The afterimage method fulfills thus the previously mentioned two thera-

*Afterimages are entoptic phenomena of retinal origin. A cortical reflection of the retinal processes cannot be denied. It appears, however, that the retina is the primary source of afterimages. In a future publication we shall discuss this subject at length and report on some of our own observations.

peutic requirements in the following way:

1. Sustained attention directed to the foveal afterimage which has the psychological value of a real object results in relocation of the spatial value "straight ahead" from peripheral elements back to the fovea.

2. The physiologic superiority of the central retina over peripheral elements is enhanced, at least in the initial stage of perception of the afterimage, as Aulhorn's investigation demonstrated.

An additional therapeutic method was presented by Cüppers, who incorporated the Haidinger brushes in the coordinator. The ability to recognize the brushes, which are created by a rotating polarized filter, is strictly an entoptic macular phenomenon, and is probably connected with the peculiar arrangements of Henle's fiber layer in the macula. In a recent publication we have expressed doubts as to whether peripheral retinal elements might not be involved in the perception of the Haidinger brushes, because a group of patients with severe anatomic damage of the macula were able to recognize the phenomenon.[23] We have convinced ourselves meanwhile that remnants of the partly destroyed macula may suffice to create the phenomenon and are now in agreement with Cüppers as to its macular origin. Initially, Haidinger brushes were utilized to treat parafoveal fixation in connection with manual exercises. Recently, however, they were incorporated in the Oculus synoptophore for binocular exercises. A macular afterimage is created in one eye, and the patient's task is to superimpose this afterimage with the brushes, which are observed with the other eye.

Pleoptics in its present form has brought great and important progress to the active treatment of amblyopia. Many patients with eccentric fixation who in the past had to be given up as hopeless can now be helped. However, more experimental evidence on the characteristics of amblyopia and the pathophysiology of this complex and fascinating impairment needs to be collected, with the ultimate goal of improving and increasing the effectiveness of our present therapeutic methods.

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III

OBSERVATIONS OF PLEOPTIC DIAGNOSIS AND TREATMENT

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THE word *observation* was put in the title of this paper for a special reason. Webster's dictionary defines *observation* as the act of regarding attentively or watching. Since pleoptics is a new approach to the attainment of full or complete vision in certain cases, it surely warrants attention. It must be given a chance to grow and develop to its full potential, which will, of course, necessitate time and patience. We must realize its possibilities and limitations as we observe the development of this new discipline.

The outline of this paper will include:

I. A brief description of the instruments and techniques advocated by Professors Bangerter and Cüppers

II. Factors to be considered in applying European techniques to patients in this country

III. How this new concept might affect some of our present methods of dealing with a case of strabismus

IV. A discussion of some procedures that might be used if pleoptic equipment were not available.

The aim of the treatment of Professors Bangerter and Cüppers is to relocate fixation to the fovea in cases of eccentric fixation and re-establish the physiologic superiority of the fovea through the elimination of the suppression processes. This is the common denominator of both techniques; variations are based on differences in theoretical concepts.

Professor Bangerter's technique is called the "dazzling - stimulating" method. The eccentric area is dazzled by a strong light, and this is followed by passive stimulation of the central or foveal area.

Professor Bangerter's work in this field dates back to 1947. Numerous instruments were modified to carry out this method of treatment. They include the slit lamp, the Gullstrand ophthalmoscope, and the Nordenson fundus camera. At the International Congress of Ophthalmology in Brussels, in September 1958, the pleoptophor was introduced (fig. 1). This is a specially designed instrument, easier to use and more compact than any of the previous instruments. It is a modified ophthalmoscope which permits observation of the patient's eye during the entire treatment procedure. The position of the patient's eye is controlled by a fixation device which is seen by the better eye. A telescopic device permits 18 times magnification of the fundus within a field of 40 degrees. The treatment is passive and not dependent upon information given by the patient; it can, therefore, be started at a relatively early age.

The actual treatment is carried out in two phases, the first being the dazzling phase. Stencils of different sizes which have spot diaphragms are used (fig. 1, lower left). The fundus is flooded by controlled light while the central area is spared any stimulus. Professor Bangerter reports that the effect of one minute of dazzling lasts from ten to twenty minutes.

tensities to break down the central scotoma.

During the second phase of passive treatment, the attention of the patient may be directed to the central stimulating light. In cases of less intensive central scotoma, a stencil with illuminated optotypes may soon be available to be used in place of the light stimulus.

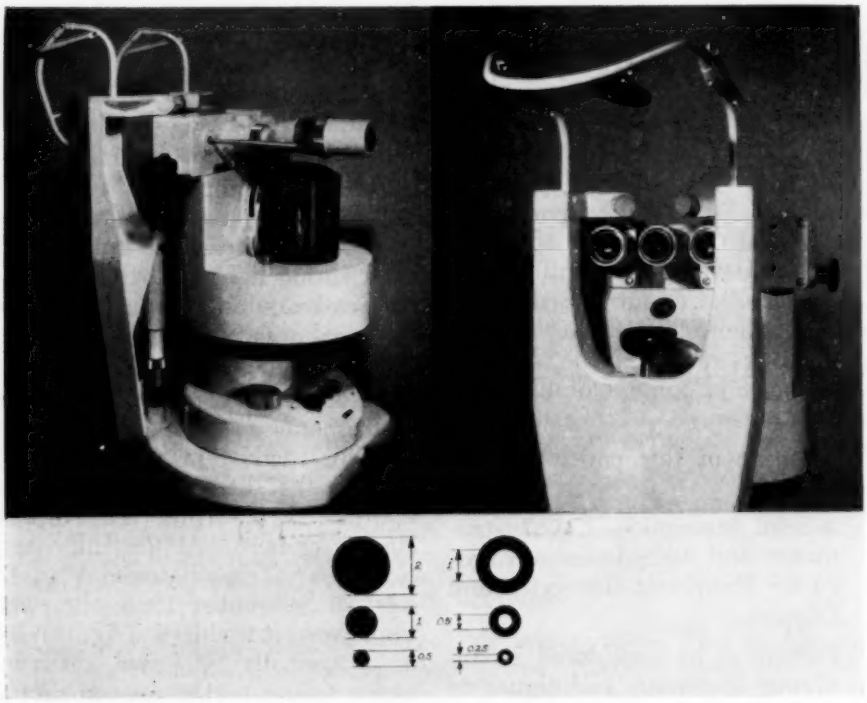

FIG. 1—(Top) Two views of pleoptophor. (Bottom) Stencils used in first (left) and second (right) phases of treatment. Number opposite each stencil is the area (in cubic millimeters) covered on the retina.

The second phase consists of illuminating the previously dazzled retina by light directed through a doughnut-shaped polarizing filter while the central area is now stimulated. This is accomplished by another set of stencils which have polarizing filters with the same outer diameter as the one used in the first stage (fig. 1, lower right). Localized central stimulation is now begun with varying light in-

The dazzling-stimulating phase on the pleoptophor is performed two or three times during each session. Immediately following exposure, auxiliary instruments are used. These are designed to develop hand-eye, and visual-auditory coordination. The names of some of these instruments are localizer, corrector and centrophore. As they are made more readily available to us in this country, the role

these instruments play in the treatment will be more generally understood.

When fixation becomes central, binocular orthoptic work is carried out. The English Lyle synoptophore is used for binocular training.

The patients are admitted to the pleoptic school or hospital for three-week periods and receive treatment

The visuscope is the diagnostic instrument and enables the examiner to observe the type of fixation present (fig. 2). It represents, in essence, an ophthalmoscope so modified that a star-shaped figure and concentric circles are projected on the fundus of the patient's eye. The patient is asked to fixate the star figure. If fixation is eccentric, the projection of the star is

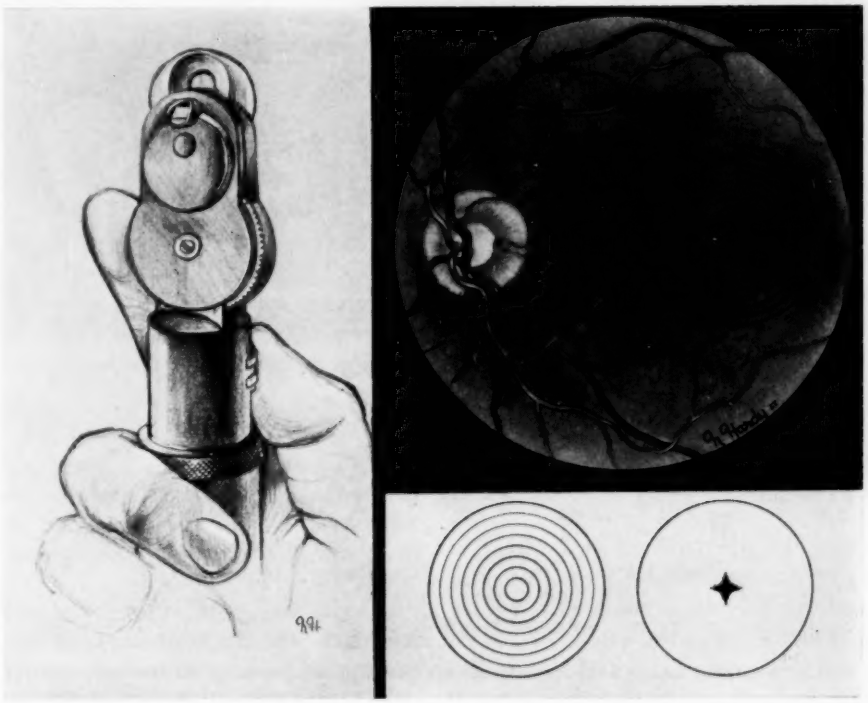

FIG. 2—Visuscope, concentric rings, star. Fundus showing star and concentric rings as projected on the patient's eye.

one hour in the morning and one hour in the afternoon. The pupil of the amblyopic eye is dilated for the therapy and the amblyopic eye is totally occluded between treatments.

Professor Cüppers of Germany has developed the technique known as the "afterimage" method. His instruments include the visuscope, euthyscope, coordinator, space coordinator and oculus synoptophore.

not located on the fovea and the relationship of the concentric circles to the fovea enables the examiner to determine the degree of eccentricity. We use a rubber stamp duplicating the eccentric rings as seen on the fundus with the visuscope. This facilitates recording the degree of eccentricity and provides a permanent means for comparison during the course of treatment.

The euthyscope, which is also a modified ophthalmoscope, is the therapeutic instrument employed to produce the afterimage. The amblyopic eye must be maintained in such a position that the examiner can visualize the central area of the fundus, and it must be held steady during the exposure. A very useful way to accomplish this is to permit the better eye to fixate a small light reflected in a hand mirror held against the nose (fig. 3).

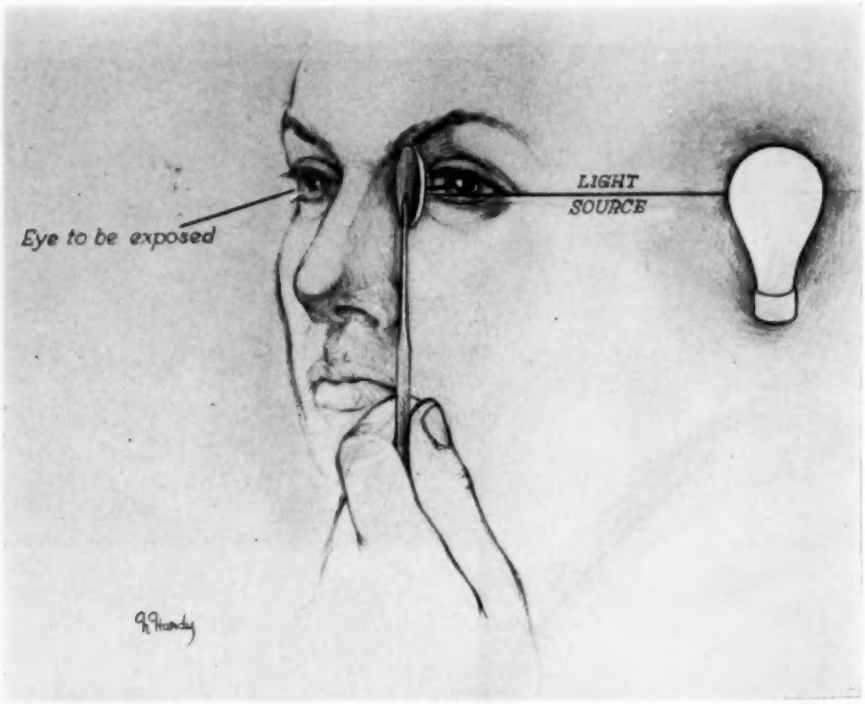

FIG. 3—Method used to bring the amblyopic eye into position for treatment with the euthyscope.

The euthyscope contains a green filter disc and two interchangeable central-spot diaphragms, three degrees and five degrees in size, respectively (fig. 4). The green filter is used until the examiner can bring the central area of the retina into view. Then the disc with a central spot diaphragm of the desired size is directed over the macular area, and the surrounding retina is dazzled for 25 seconds. The patient is then asked to close his eye and see whether he can appreciate the positive afterimage, which is a white circle with a black center (fig. 5). If he can appreciate this, he is then seated in front of a white screen and with the aid of a flicker light (which regulates the light and dark phases), appreciation of the negative afterimage is encouraged. The negative afterimage will appear when the light is on and will look like a doughnut or lifesaver having a bluish grey periphery and a white center. The rapidity with which the patient can appreciate the negative afterimage is of considerable value in determining

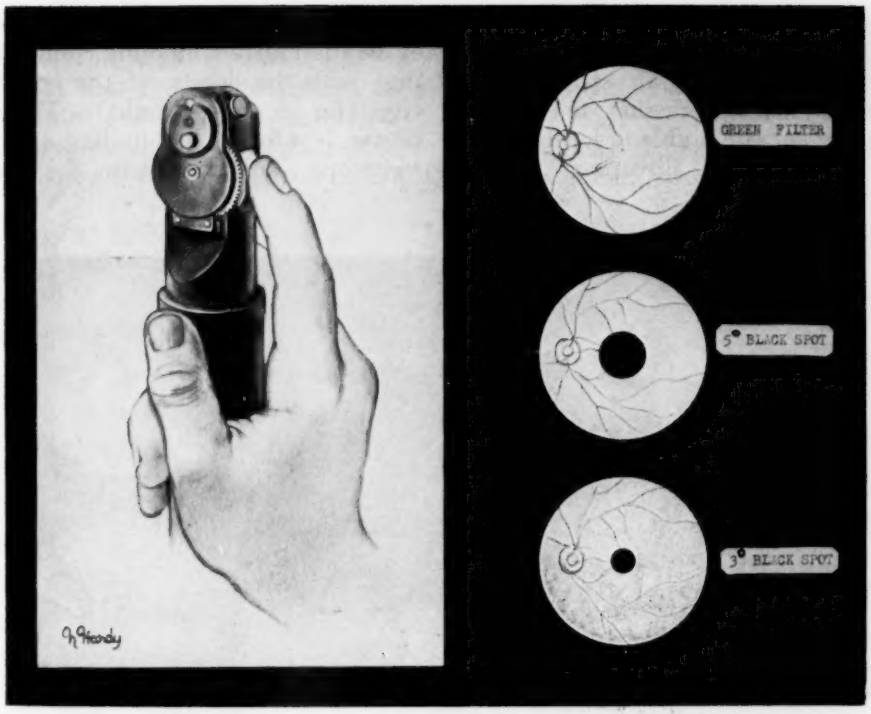

FIG. 4—(Left) Euthyscope. (Right) Top—green filter disc; center—5° black spot; bottom—3° black spot.

the prognosis. If, after repeated attempts, the patient is unable to perceive the negative afterimage, the prognosis is considered to be guarded or poor. Exposure to the euthyscope is repeated many times, and the subjective appreciation of the negative afterimage is encouraged. The patient will come to recognize the white center of the afterimage as the position of his central area in space.

The coordinator, space coordinator, and the modified synoptophore all utilize the Haidinger brush phenomenon. This phenomenon occurs because the arrangement of the nerve fibers in the fovea of a normal eye polarizes light that strikes it. If a polaroid filter is placed between a light source and the patient, and is made to rotate before a normal eye, the nerve fibers act as analyzers, producing the appearance of a brushlike object visible to the eye, called the Haidinger brush. Since the fovea is a spot, the brush spreads into the macular area. The fovea is represented by the center, like the knot of a bow tie. The Haidinger brush is used

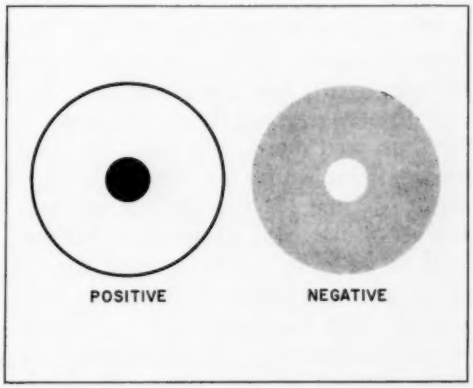

FIG. 5—Positive and negative afterimages.

for the purpose of testing the presence of foveal function. It is also used to check the positions in space of the foveal visual impression to be sure that the patient is able to localize it in the straight-ahead direction.

they will be displaced from the point of fixation in an amount commensurate with the degree of the eccentricity (fig. 6, lower right). This, of course, confirms the findings of the visuscope. Treatment-wise, the goal is

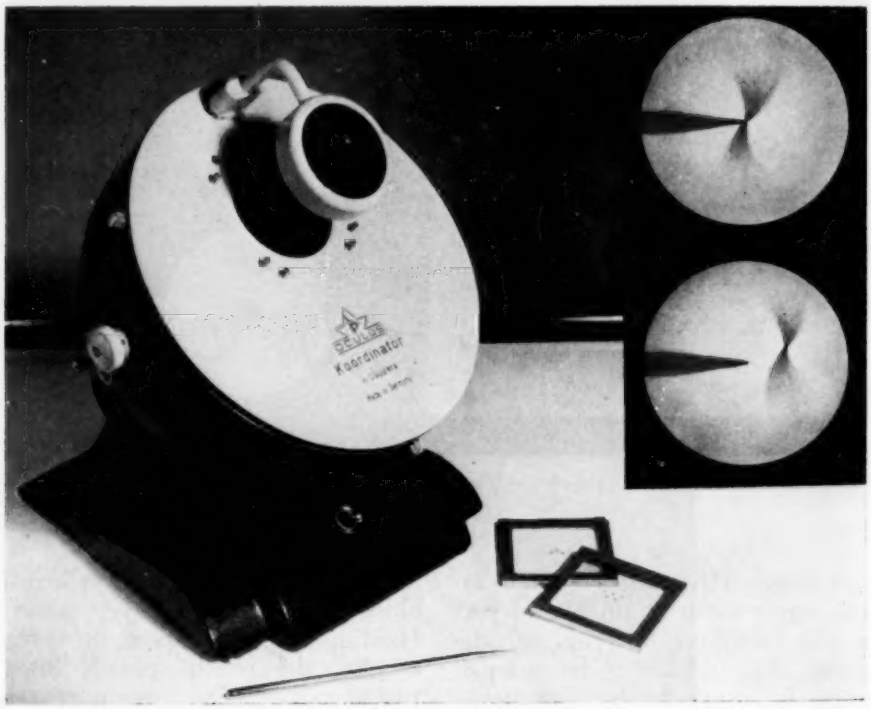

FIG. 6—Oculus coordinator with slides and pointer. (Upper right) Central fixation. (Lower right) Eccentric fixation.

We can now understand why Professor Cüppers made use of this phenomenon in his instruments. The coordinator is useful in diagnosis as well as treatment (fig. 6). Its diagnostic value confirms the findings of the visuscope. If the patient has central fixation, the Haidinger brushes will be seen to rotate around the tip of a given fixation point such as a pointer (fig. 6, upper right). The patient who has eccentric fixation, within 6 degrees of the fovea, should be able to appreciate the brushes, but to have the patient bring the brushes to the point fixated, thus encouraging central fixation and correct localization and projection. Several slides come with the instrument to add variety for the patient. This instrument is extremely useful in cases of eccentric fixation of small degree.

The space coordinator grew out of the necessity for developing correct localization of the foveal area in relation to the negative afterimage. In the early stages of Professor Cüppers'

work, optotypes were held up in the center of the negative afterimage in the belief that the patient would use his macular area to see them. It was soon discovered, however, that since the margins of the negative afterimage were not totally blacked out, some of the patients would make an attempt to see the optotype with their eccentric area. A better control was needed and the space coordinator came into existence.

The features of this instrument are:

I. The field can be varied in size by special diaphragms built into the apparatus.

II. A slide with optotypes varying in size can be introduced.

III. The instrument can be used at a distance of four feet or more from the screen.

The patient is invited to look into the instrument, which has been set up using the largest field (fig. 7). He is asked to locate the Haidinger brushes. If he can be aware of them in the center of the field, an optotype is introduced. In some cases, as the E is viewed, the brushes completely disappear or are displaced to the side. He then is encouraged to see the optotype with the brushes rotating around it. The ultimate goal is to have the patient maintain the brushes around the smallest E within the smallest field possible.

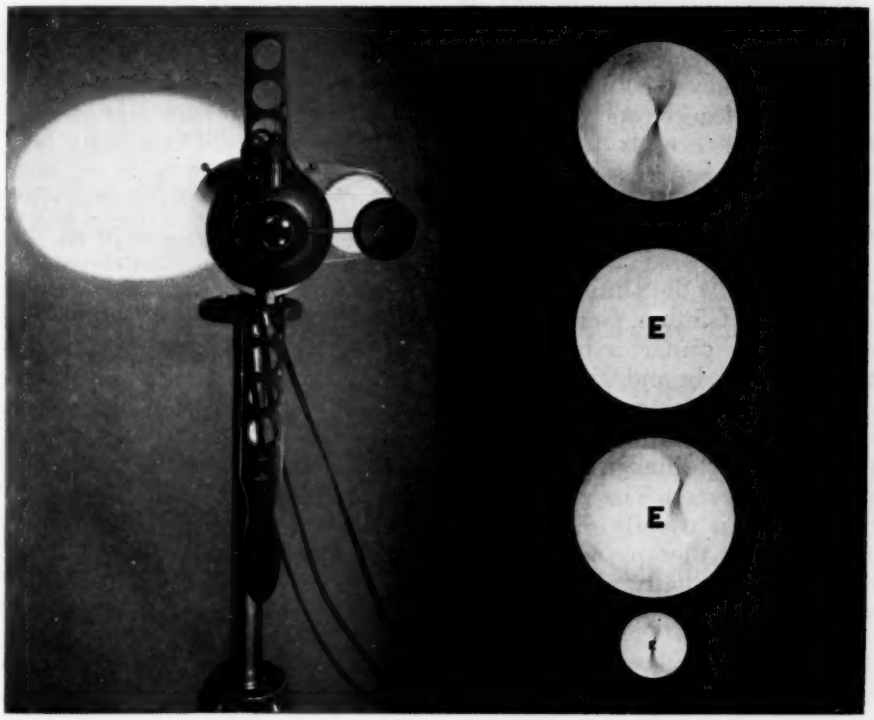

FIG. 7—Space coordinator. (Right) Decreasing field demonstrated with use of optotypes and Haidinger brushes.

The treatment up to this point has been monocular. When the fixation becomes central, binocular work is commenced. Cüppers employs the oculus synoptophore for this purpose. This synoptophore is a major amblyoscope incorporating the Haidinger brush phenomenon. At this stage in the treatment, a goodly number of cases demonstrate anomalous retinal correspondence. Professor Cüppers has devised techniques to be used with the synoptophore. Since anomalous retinal correspondence is outside the scope of this paper, these techniques will not be dealt with in this presentation.

The patients in the clinic of Professor Cüppers in Giessen, Germany, are admitted to the center or hospital for three-week periods and given hourly sessions in the morning and afternoon. The average age at which active treatment with the afterimage method can be started is 6 years. The pupil of the amblyopic eye is usually dilated with atropine for the therapy and the amblyopic eye is totally occluded between treatments.

Having completed our brief comments on instruments and techniques of Professors Bangerter and Cüppers, let us mention some factors to be considered in applying the European techniques to patients in this country.

How can we arrange to have patients available for two hours of work each day? In Europe the educational systems are agreeable to excusing the patient from school for this type of therapy. This does not hold true in our country—at least, not in New York City. It is difficult to have a child excused for even one or two hours of a school day. Vacations during the school term permit a week or ten days at the most. Can we expect to obtain good results in these cases when the patient is seen for only two or three hours a week, as compared with the cases in which the child is seen ten or twelve hours a week, as in European centers?

It is our duty to work out a therapeutic program effective enough to make school absence worthwhile and to convince the teachers and parents of the importance of this treatment. Amblyopia treatment should be given its proper emphasis. To quote Sir Stewart Duke-Elder[7]:

> No hesitation is ever felt in treating impending blindness from glaucoma as a matter of urgency, or in calling in all the forces of medicine to prevent the loss of central vision in cases of spreading choroiditis, but the blindness of amblyopia or the development of a central scotoma in a squinting child is too often dismissed with the vain hope that the patient will grow out of it or that the deformity will eventually rectify itself.

Another plan put forth by some in this country suggests hospitalization in order to render intensive treatment. Here, again, many factors must be considered. The shortage of hospital beds in many areas makes it impossible to arrange for a three-week admission, and the high cost of hospitalization is almost prohibitive. Last, but surely not least, there is the effect of such an undertaking on the patient. In Europe the centers have the unique atmosphere of family-type living. This may be due in part to the fact that a goodly number of the patients come from small communities and relish the association with other children. They do not have any fear of hospitals; in fact, some I saw were not anxious to be discharged after the treatment was completed.

Thus far we have concerned ourselves with the physical setup for rendering treatment. Now we come to the psychological aspect of the treatment, which requires mental ef

fort on the part of the patient. It must be stressed that since Professor Bangerter's new pleoptophore has not been available to use here in this country until just recently, the work in our office to date has been primarily with Professor Cüppers' method. This method is largely subjective and, therefore, requires the undivided attention of the patient. The patients in Europe were attentive and worked hard during their hourly sessions. They knew they had a job to do and they did what was required of them. The average child here, however, exhibits a restlessness whenever he is asked to do things that are repetitive. Looking repeatedly for the afterimage doughnut, or lifesaver, on a screen, or watching a brushlike propeller is not entertaining enough to hold the patient's attention. It can be if the patient is sufficiently mature to understand what his reward will be for all the work. This is the secret to success. It is not enough that the parents want, or the doctor wants, or the technician wants the patient to see better. The patient must have a desire and goal of his own. Unless the patient has the will to succeed on his own, no good will come of all the effort.

Will this new concept affect some of our present methods of treatment now that the study of amblyopia has taken on a much broader meaning? It might be well to list briefly some pertinent points which could influence our present line of thinking.

A. PATCHING.

WHICH EYE SHOULD BE PATCHED?

The literature from Europe states that patching of the good eye in cases of eccentric fixation will lead to reinforcement of the eccentric area rather than bring about a change in the fixation pattern. In reference to children from 3 to 5 years of age this statement should be qualified. Within this age group, if the amblyopic eye has not developed a fixed area of eccentric fixation, patching the better eye may be attempted. However, with caution! Very frequent checks should be made to determine what pattern the amblyopic eye is developing. If the visuscope reveals an unsteady or variable fixation pattern, occlusion of the better eye may be continued with the hope that eccentric fixation may not be too firmly engrained and may respond to this type of treatment. If the fixation is one in which a definite eccentric area is being used, then patching of the better eye is contraindicated.

In view of this, the following are some questions we might ask ourselves:

I. Could some of the patients whom we have classified as having intractable amblyopia fall into the category of eccentric fixation?

II. Is it possible that the impression that vision will not improve after the age of 10 years could stem from the fact that these patients may have eccentric fixation? If proper treatment were given, might not the vision still improve?

III. Is there such a thing as amblyopia of arrest, or is it amblyopia based on the area of the retina that the patient uses for fixation?

IV. With the visuscope now available, are we not in a better position to guide treatment with better understanding?

B. CORNEAL REFLEXES

Although we have worked with pleoptics for a limited time only, it

has become apparent to us that no longer can one rely on corneal reflexes to determine the type of fixation. A marginal eccentric fixation of small degree can lead the examiner to believe that fixation is central when it is not. More accurate and finer tests must be employed to give the examiner the correct information.

C. PRISM AND COVER TEST

The extreme form of eccentric fixation that has been seen by all of us at one time or another is the one in which the eye does not make any movement to look at a given object. The eye stays in its deviated position even when the better eye is covered. We know now, however, that there are patients whose amblyopic eye does not have true central fixation, yet makes a movement of redress when the better eye is covered. In the light of this knowledge, the question arises, "How accurate is the measurement found with the prism and cover test?" Should one not introduce a correction factor based on the visuscope determination of the fixation pattern, in cases of amblyopia?

D. TSCHERMAK AFTERIMAGE TEST

Bielschowsky stated that central fixation was a prerequisite for the validity of this test. In the past we have assumed central fixation was present when there was no gross eccentric fixation, and we have used the test on that basis. How accurate was our information in certain cases?

E. VISUAL ACUITY

This is an area that requires most careful study. The necessity for standardization is evident now and will become more so as time marches on. The differences in visual acuity as tested by isolated optotypes compared with whole lines is not new to us. At one time or another each one of us has had a patient with 20/30 vision, single E's; yet the same patient tested 20/70 or less with whole lines of E's or numbers. The significance of this finding is becoming better understood. Professor Bangerter has named it "separation difficulty" and has pointed out that it is found in patients who do not have central fixation.

In testing young children it is necessary to use single E's because of their brief attention span. As they mature, whole line charts can be used. Even in this area there is a marked difference in the results obtained, depending on the chart used (fig. 8). It is of prime importance that a notation be made as to what chart has been employed in taking the visual acuity, since it may influence the examiner's disposition of the case.

Lastly, a few words concerning some helpful aids that might be used if pleoptic equipment is not available to you in your respective offices or centers . . . .

The analysis of a case of strabismus should include the taking of the visual acuity with isolated optotypes as well as with whole lines. A difference of two lines or more in the "separation visual acuity" may indicate that central fixation is questionable.

When using the prism and cover test, special note should be made of the strength of prism found to stop the movement as well as the strength of the one that reverses the movement. Careful records should be maintained for the future study of cases showing a 10 to 15 prism diopter difference.

A very useful diagnostic aid, which can be homemade, is a modification of the instrument Professor Bangerter invented and named the corrector. Take an index card and draw black

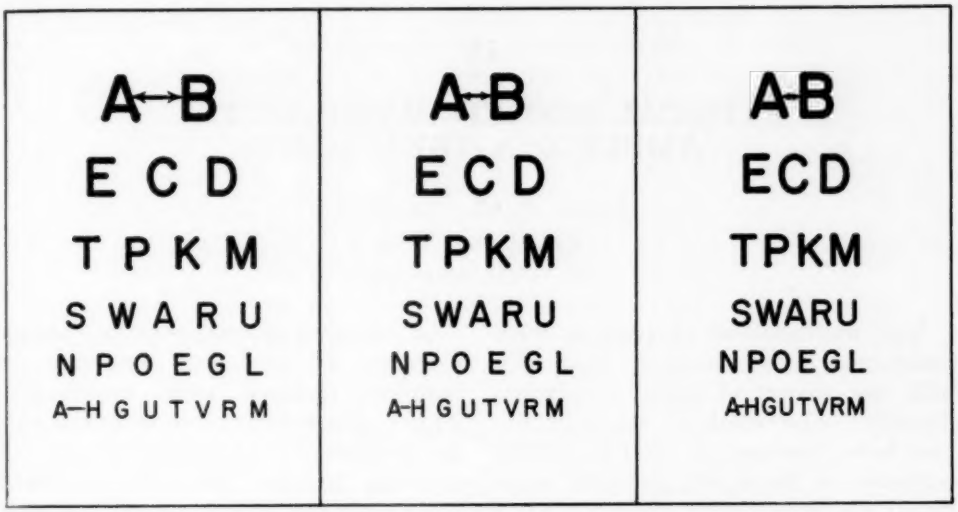

FIG. 8—Charts illustrating various separations on the lines of acuity testing.

dots on it varying in size from 1 mm. to 10 mm. The patient, with his better eye occluded, is asked to point with the tip of a pencil to the dots. One can observe readily whether he has difficulty in localizing. This card is a diagnostic aid, since in cases of eccentric fixation the patient tends to past-point in a manner similar to that of patients who have experienced a recent paralysis of one of the extraocular muscles.

We have been working with pleoptics for a little over one year and are not yet in a position to make statements regarding therapeutic results. The experiences that we have had so far with our work in pleoptics are comparable to those attending the care of a newborn infant. One cannot rush growth and development. We feel that time and patience will be rewarded. We are convinced that pleoptics sheds invaluable light on diagnostic problems. As to its value in treatment, the answer will come with the passage of time and the accumulation of experience.

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IV

CLINICAL RESULTS WITH ACTIVE AMBLYOPIA TREATMENT

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THE management of patients with amblyopia has changed markedly with the advent of active amblyopia therapy. The methods used in the past have consisted of total or partial occlusion of the fixing eye. An occasional attempt was also made to change the fixation by patching the amblyopic eye. More recent methods which require the participation of a trained individual for therapy have become popular in European clinics. Such techniques are usually called "pleoptics."

The newer forms of therapy depend upon the subject identifying his macular area so that suitable training forms may then be imaged upon the central retina. Most commonly used is the afterimage method of Cüppers. This technique requires a hand ophthalmoscope (euthyscope) which projects a ring of light that surrounds the macular area. By this device an afterimage is created with a sharp distinct border encircling the normal point of fixation. By alternating the room illumination between light and dark, the afterimage is prolonged. Ultimately the patient is required to center the afterimage over letters that are decreased in size as the visual acuity improves.

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A modified ophthalmoscope (pleoptophore) is used by Bangerter in training patients with amblyopia. This instrument is table-mounted and has facilities for bleaching the area of eccentric fixation. Immediately afterward, objects are projected on the macular area for training. The placement of the image is under the control of the examiner, while this is not true of the method of Cüppers.

The period of training lasts from thirty minutes to an hour, and patients are treated from three times a week to twice a day. The length of therapy may be six weeks or longer. Patching of the amblyopic eye is continually used until the patient has obtained central fixation and visual acuity sufficient for his needs; then the occlusion is changed to the dominant eye.

During the past twenty months we have used the method of Cüppers almost exclusively in the treatment of patients seven years old or older. The subjects were obtained from the Washington University motility service and from ophthalmologists in private practice. Twenty-five patients have been treated a minimum of ten times, with sessions lasting at least thirty minutes, either three times a week or daily. The average number of training periods was eighteen, and the greatest number was twenty-eight. Visual acuity with single letters was

TABLE I
PRETREATMENT FIXATION AND VISION

	NO.	20/80+	20/200+	20/200−
Foveal	3	1	1	1
Parafoveal	5	3	2	0
Paramacular	6	2	3	1
Gross Eccentric	11	0	2	9
Total	25	6	8	11

TABLE II
POST-TREATMENT VISION

	NO.	20/40+	20/100+	20/200−
Foveal	3	2	1	0
Parafoveal	5	5	0	0
Paramacular	6	2	3	1
Gross Eccentric	11	1	0	10
Total	25	10	4	11

20/60 or worse in the amblyopic eye. Between therapy sessions the amblyopic eye was patched until steady central fixation was obtained. After this had been accomplished, patching of the better eye was instituted. The patients with visual acuity from 20/70 to 20/60 were treated without occlusion or occlusion of the amblyopic eye only.

The subjects were classified according to their initial fixational pattern into foveal, parafoveal, paramacular, and eccentric fixation by the visuscope. The fixational pattern and visual acuity level with single letters are listed in table I. Fourteen patients had fixation in or about the macular area, and in twelve there was an acuity of 20/200 or better. The majority of subjects with gross eccentric fixation had a visual acuity of less than 20/200 (82 per cent).

The visual acuities obtained after therapy are listed in table II. Visual improvement was noted in fourteen patients (56 per cent). Most of the patients who obtained vision of 20/40 or better were those who also had some form of macular fixation (90 per cent). Three patients with paramacular fixation improved to a level of 20/100 to 20/40. Ninety-one per cent of the individuals with gross eccentric fixation remained with visual acuity of 20/200 or below.

It has been stated that euthyscope therapy is unsatisfactory or tends to enforce parafoveal fixation. We have not encountered difficulty treating this type of fixation with the euthyscope. The alterations of fixation (table III) from therapy was toward a more foveal position in patients who previously imaged around the macular area. All of the patients with para-

TABLE III
POST-TREATMENT FIXATION

PRETREATMENT	NO.	FOVEAL	PARAFOVEAL
Parafoveal	5	5	0
Paramacular	6	2	3
Gross Eccentric	11	1	0
Total	22	8	3

foveal fixation shifted to a foveal position. Two of the six in the paramacular group became foveal; three developed parafoveal fixation; and one remained paramacular. In only one subject with gross eccentric fixation was there a change in the pattern, and this was to a foveal position. This patient also obtained an acuity of 20/40.

During the first two weeks of therapy, it was noted that the patients who ultimately improved to 20/100 or better would respond rapidly. The subjects with minimal improvement would demonstrate an insignficant change over this period. This response seems a reliable indication for the continuation of training. In the patients reported in this study, this criterion was not used, however, since we were concerned with the best results possible.

When the results were compared to patching, the following features were noted: (1) improvement in visual acuity was more rapid but not necessarily superior; (2) older patients could develop an acuity in the amblyopic eye sufficient to tolerate patching of the dominant eye; (3) the patients in general accepted this therapy more readily than occlusion of the fixating eye.

At the start of therapy, difficulty was experienced in producing an afterimage. This was usually due to the inability of the patient to hold his eye still, or lack of intensity of the afterimage. Most of these problems have been overcome by the help of Dr. K. S. Noyori, who has designed a small euthyscope that contains an electronic flash (fig. 1). This instrument includes both features of the visuscope and euthyscope; in addition,

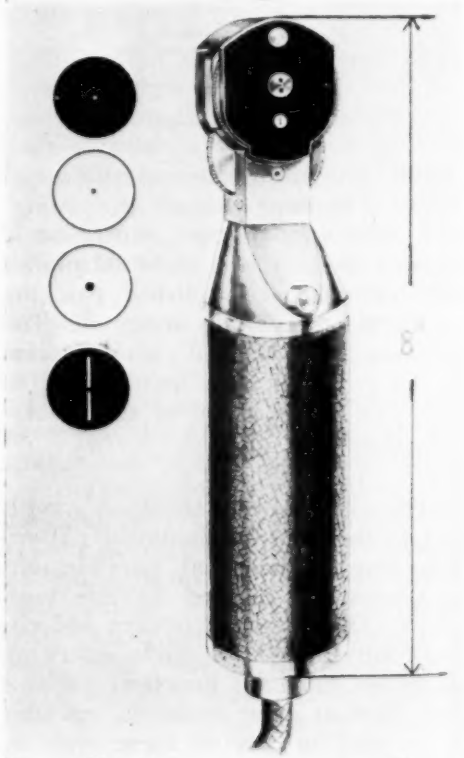

FIG. 1—A training ophthalmoscope similar to the euthyscope. This instrument contains an electronic flash as well as four patterns. The spot is for fixation, the two circles for training, and the line to determine anomalous retinal correspondence (ARC). The small training circle is very effective in parafoveal fixation.

the classic line for determining retinal correspondence is used. All of these innovations have made it possible to use one device to obtain the fixational pattern and retinal correspondence in patients with eccentric fixation. Afterimages of various intensities may be produced rapidly, and up to three patients have been treated during the same session.

perience gained, the orthoptist must acclimate herself to the flickering illumination during a very repetitious procedure with a usually reluctant child.

A method which eliminates many of the problems of expense and experience is shown in figure 2. This technique requires an intensely illuminated white or silver screen on which

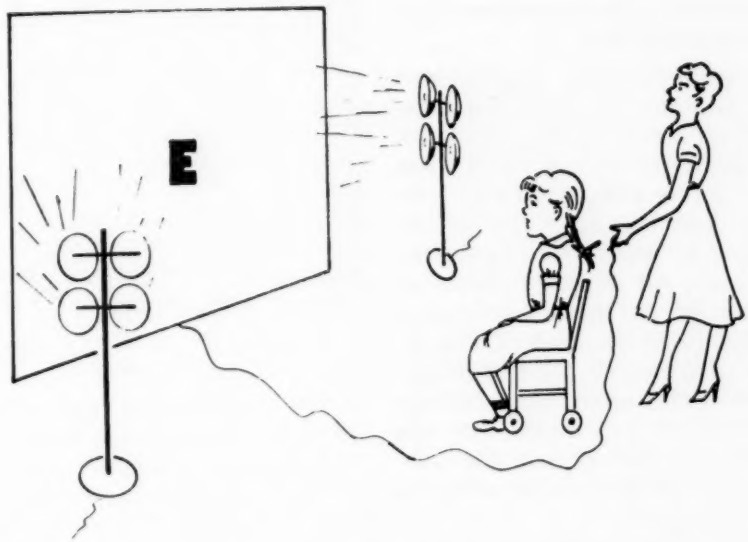

FIG. 2—Lighted screen technique for amblyopia training. Eight no. 2 reflectospot photographic lamps are used. The training letter is rotated by a motor behind the screen. With improvement of visual acuity, the size of the training letter is reduced.

Use of the euthyscope requires an examiner who is familiar with ophthalmoscopy and who can locate the macular area in a subject with wandering fixation. Quite often the amblyopia is associated with an esotropia, and the eye is nasally rotated. This makes visualization difficult. There is also the factor of expense. All of the currently available instruments are imported and manufactured in limited quantity. Once the instrument has been obtained and experience gained, the orthoptist must acclimate herself to the flickering illumination during a very repetitious procedure with a usually reluctant child.

A method which eliminates many of the problems of expense and experience is shown in figure 2. This technique requires an intensely illuminated white or silver screen on which is mounted training E's of various angular size. The patient sits in front of the screen with the pupil of the amblyopic eye dilated and the other eye occluded. Identification of the object and its direction is made.

To prevent retinal adaptation, the eye is covered at intervals of ten seconds for three to four seconds, and the position of the object is changed during this interval. The training periods last thirty minutes and are

given daily to three times a week. Between training sessions the amblyopic eye is patched until a level of 20/60 is reached; then the dominant eye is occluded.

This training system was developed following the observation that visual acuity improved in amblyopia with increased illumination. Since the letters used in therapy are black, contrast is also enhanced. In addition, the intermittent exposure served to attract the subject's attention. With periodic training, this improvement in acuity is maintained.

Eleven patients have been treated at least nine times. In this group were seven gross eccentric fixators with vision of 20/200 or less. Four of these developed an acuity of 20/100, one of 20/50, and the other 20/60. In the group (4) with fixation in the macular area, all obtained vision of better than 20/70, and in two cases 20/20 vision was obtained. These results are preliminary, and with enlargement of the series more definite conclusions may be drawn. At the present time it appears that this technique is superior in cases of eccentric fixation.

One of the striking features in patients with amblyopia was their social and economic status. Most of the patients in this series were from families with limited finances. This was true of the private patients as well, since the majority of these were of borderline clinic status. Amblyopia is predominantly a condition of neglect, and in our series the parents were aware of the problem from school examinations. For various reasons they had avoided the issue.

Once an attempt was made to undertake training, the parents' attitude became apparent. Numerous appointments would be missed and several patients achieved their results due to the orthoptists' insistence. Fifteen patients who were started on training failed to complete ten sessions in spite of appointments being scheduled at the patient's convenience. There was no charge for therapy.

The cost of such training must also be considered, since eighteen sessions was the average, and the usual orthoptic charge spaced over a six-week interval would appear excessive to most of these parents. All of these factors would seem to indicate that public health support is needed for active amblyopia therapy.

SUMMARY

We have found that euthyscope training of patients with amblyopia is an effective technique, provided that at least paramacular fixation is present. It was much less effective in eccentric fixation. The results obtained are more rapid than occlusion alone. The response to therapy in the first two weeks was a reliable index for continuing training.

A method has also been described that is less complicated than euthyscope therapy, and preliminary results with eccentric fixation were superior.

V

PLEOPTIC TREATMENT OF AMBLYOPES WITH CENTRAL AND ECCENTRIC FIXATION

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THE diagnosis and treatment of amblyopia have undergone considerable changes within the past few years. Now and again new methods have been reported, but none seem to have reached the scope of the methods proposed by Dr. Bangerter and by Dr. Cüppers. These methods have made contributions both from the practical and from the theoretical points of view, but they should still be considered to be in the process of development. Along with Bangerter's and Cüppers' pleoptic treatment, a method proposed by Bietti which employs anti-inhibitory drugs is worthy of note. The use of anti-inhibitory drugs has shown some interesting results in certain types of amblyopia. However, before presenting the practical methods and results of pleoptic treatment and anti-inhibitory drugs, it may be of interest to present a few words on the theories of Bangerter and of Cüppers in an attempt to show their main differences and similarities.

Though both Bangerter and Cüppers make use of afterimages, the theoretical implications are completely different. The method of scotomatization should be referred to as Bangerter's method, while the method of the afterimages or (better still) "reversion of the afterimage" should be referred to as Cüppers' method. The main difference between the two methods appears to be in their interpretation of eccentric fixation. Bangerter follows the classical clinical concept that visual acuity in amblyopes may be lower in the foveal area than in the surrounding points, so the patient chooses that part of the retina offering the best functional possibilities. There is an inhibitory macular scotoma, and somewhere at the limit of this scotoma there is the newly acquired area of fixation. According to this concept, Bangerter attempts to reduce the function of the eccentric or peripheral area chosen for fixation by "dazzling" with strong light, sparing the macula, followed by intermittent light stimulation of the fovea. There is a temporary inhibition of the area that has been dazzled, and during this period the area is nonsensitive for further stimulation (as has been pointed out by Adler[1]). The use of the intermittent light stimulation of the fovea tends to eliminate the foveal inhibitory scotoma. The explanation offered for this phenomenon is that with intermittent stimulation, attention is called to the foveal area and retinocortical conduction is improved by having a direct effect on the synapses (Tittarelli-Graemiger[12]). Bangerter here differs from Cüppers in that he places no emphasis on the afterimage. The "dazzling and stimulation," as shall be shown, is a passive method.

The "dazzling and stimulation" in the Bangerter method is accomplished

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by the use of the pleoptophor, an instrument made up of the Zeiss slit lamp, Gulstrand ophthalmoscope and Nordenson camera.

This can be considered to be the main step in the treatment of eccentric fixation according to Bangerter. A variety of secondary disturbances associated with amblyopia are symptomatically treated with the help of various instruments. Sensorimotor disturbances such as occur in hand-eye coordination are characteristic of amblyopia with eccentric fixation and may be corrected with the localizer, acoustic localizer, and corrector. Other disturbances believed to be cortical, such as difficulty in the separation of forms in a row, are treated by using the "separation trainer." Pleoptic games such as pricking and tracing are also suggested by Bangerter to complete the treatment when the patient has acquired central fixation.

Cüppers' treatment is based on new concepts regarding eccentric fixation of the amblyopic eye. However, the treatment of amblyopia by the afterimage method should be divided into two parts—treatment of amblyopia with eccentric fixation and treatment of amblyopia with central fixation.

Concerning amblyopia with eccentric fixation, he believes with Bangerter that there are inhibitory factors that may lead to a macular scotoma, but he feels that this is not the most important or, at least, not the sole factor in determining eccentric fixation. According to Cüppers, the acquisition of an eccentric area of fixation depends on a change in the spatial values of the retina similar to the one occurring in binocular vision and commonly known as *anomalous correspondence*. In some cases of eccentric fixation, the change in the spatial values of the retina acquired in anomalous correspondence (binocular) tends to remain also in monocular vision (a concept also reported by Duke-Elder[11]) and the eccentric area of fixation acquires the straight ahead value of the macula. It becomes obvious from Cüppers' point of view that merely dazzling the eccentrically fixing area, as Bangerter does, should not change the newly acquired spatial value of the retina and therefore should not restore central fixation. There are similarities, according to Cüppers, between anomalous correspondence and eccentric fixation which we should like to emphasize. As is well known, anomalous correspondence is more easily revealed with tests simulating normal conditions (for example the synoptophore) than with tests introducing artificial conditions (such as the afterimage test). This is also true in testing eccentric fixation. The visuscope is an example of an instrument used under conditions simulating normal. However, unusual conditions (such as the euthyscope afterimage) are more apt to elicit the innate spatial value of the retina and of the macular area. When an afterimage is produced around the macula of the amblyopic eye, sustained observation of the central zone may help in recovering central fixation. This is due to the fact that the afterimage is a stimulus farther removed from conditions of casual seeing, and thus one which more easily corrects the spatial localization. This is more or less the basis of the afterimage method introduced by Cüppers for treating eccentric fixation.

In the treatment of eccentric fixation, the problem is, however, one not only of correcting the localization but also of eliminating central inhibition. This is also one of the main problems of patients with amblyopia who have

normal localization, that is to say, those patients with amblyopia who retain central fixation. The treatment is an anti-inhibitory one and also takes advantage of the afterimage. An afterimage all around the macula is provoked either with the euthyscope or with a flash, just as it is done for eccentric fixation. A normal subject will perceive a negative afterimage on a white, illuminated screen (the outer dark circle is the afterimage and the center light zone corresponds to the nonstimulated area) and a positive afterimage is seen in the dark (a white outer circle with a central dark disc). An amblyopic patient with central or eccentric fixation usually sees a positive afterimage during the light phase. He should attempt to change or reverse the afterimage, that is, to be able to perceive a negative afterimage during the light phase. According to Cüppers, the difficulty in obtaining the inversion of the color in the central part, corresponding to the macula, is due to inhibitory factors existing in this area. Some amblyopic patients with central fixation will report the reversion after a few minutes and be able to maintain it; others will require three or four sessions before they are able to report the reversion of the afterimage. When a change is obtained, it indicates that the inhibition in the macular area is being diminished or eliminated; consequently, an augmentation of the visual acuity can be expected. Cüppers uses an intermittently flashing alternoscope not only to prolong the afterimage but also to facilitate the reversion of the afterimage so as to keep the subject in a surrounding continuously changing from a light to a dark phase.

In summing up, there appear to be two advantages to the afterimage method. One is due to the fact that the afterimage more easily elicits the normal spatial value of the retina; therefore, prolonged sustained attention of the afterimage can bring about central fixation. The second advantage is due to the anti-inhibitory effect elicited by the *inversion* of the afterimage, which aids in restoring the functional value of the macula.

The Haidinger brush phenomenon (coordinator) may also aid in restoring and stabilizing central fixation. With appropriate exercises the Haidinger brushes appear to help in correcting hand and eye coordination. Since the Haidinger brush phenomenon is visible only at the fovea, it provides one more tool to draw attention to the macular area.

A further comment is necessary regarding the theory of Cüppers, because misunderstanding of certain facts may lead to an erroneous choice of treatment. As has been mentioned, Cüppers believes eccentric fixation can be acquired because a change of the retinal spatial values of the deviated eye found in binocular vision (anomalous correspondence) may be carried over into monocular vision (eccentric fixation). In eccentric fixation, the eccentric area acquires the straight-ahead value of the macula (in monocular vision). However, just as normal and anomalous correspondence may persist in certain situations, leading to binocular triplopia in binocular vision, a similar phenomenon may occur in monocular vision in the amblyopic eye if the innate and acquired spatial values of the retina show up simultaneously.

In consequence, monocular diplopia may occur in amblyopia under treatment (an observation first made by Bielschowsky). A second consequence may be that the amblyopic eye will see isolated symbols better than symbols in a row. Why is this? The

strabismus is usually a horizontal squint and the eccentric area is frequently found on a horizontal meridian. The symbols are usually presented in a horizontal row so that macula and eccentric area are simultaneously stimulated. According to Cüppers, the competition between these two areas may generate confusion. Cüppers further states, as proof of this confusion, that if rows of symbols are placed vertically instead of horizontally (when the deviation is horizontal), the visual acuity may be higher.

The second consequence is the more important from the therapeutic point of view (fig. 1). For example, if the

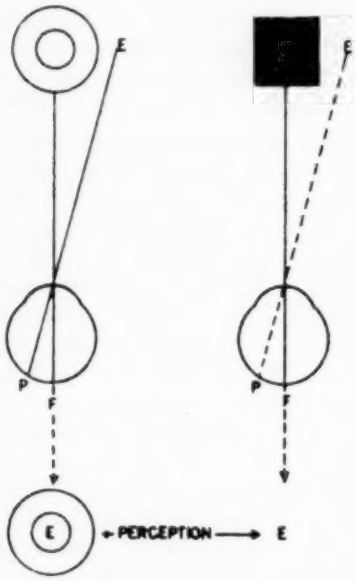

FIGURE 1.

usual circular afterimage is produced by the euthyscope around the macula, we know that the central disc corresponds to the macular projection in space. If the patient is directed to place an *E* or another fixation object inside the central disc in order to exert the macular function and if he succeeds in doing so, one may believe that the patient is exercising the macular area. This, however, according to the theory of Cüppers, is not always the case. In fact, the afterimage may elicit the normal spatial value of the macula while the real object (the *E*) may elicit the straight-ahead spatial value of the eccentric area. Both objects will, therefore, be *cortically* placed straight ahead and so *perceived as superimposed.* In such a case the wrong pattern will be exercised. If, however, the area where the afterimage is projected is darkened, this will change color or will disappear while the *E* continues to be perceived. To control this situation, Cüppers has devised a technique called "the decreasing field test," in which he uses the Haidinger brush phenomenon projected into space instead of afterimages*

Though the theoretical backgrounds of the techniques of Bangerter and Cüppers are fundamentally different, the main practical approach does not seem to differ greatly. Bangerter dazzles the eccentric and the peripheral area of the retina, using a strong light but sparing the macula. Cüppers provokes an afterimage with the euthyscope in the same area, also sparing the macula. However, Cüppers does not use strong illumination because he believes that it may provoke a secondary inhibitory effect on the spared macular area. Bangerter stimulates the spared macular area, while Cüppers makes the patient aware of the spatial projection of the spared area and its change of color (or reversion). Visual stimuli (a separated

*Looking through the rotating polaroids, the Haidinger brushes are seen rotating on a luminous white screen where there is a symbol (for example an E). The white screen around the E is progressively concentrically darkened. If the Haidinger brushes are perceived superimposed on the E, despite the fact that it is in reality projected in a different spatial point from the symbol, they will disappear while the E continues to be perceived.

E or other test object) are then added. The Bangerter treatment has the advantage that it is a more passive form of treatment from the standpoint of the patient and can be used with young children, since it requires less cooperation than Cüppers' technique. The technique of Cüppers has the advantage that it employs instruments that are simpler and less expensive.

In addition to Cüppers' method of treating amblyopia with central or eccentric fixation, we have also used an anti-inhibitory drug, strychnine, as proposed by Bietti. Strychnine was used either in conjunction with pleoptic treatment or alone in certain types of amblyopic patients. Bietti's anti-inhibitory treatment of amblyopia is also a new approach to the subject. Bangerter and Cüppers use appropriate types of stimulation to open the synaptic block that is supposed to be located somewhere along the visual pathway. Bietti has used various types of anti-inhibitory drugs (oxygen, vasodilators, vitamin B_1) with success, not only for amblyopia but also for the suppression phenomena found in binocular vision. At least experimentally, many of them seem to have some anti-inhibitory effect; but when evaluated in practical application, strychnine has been demonstrated to be more effective in amblyopia. Strychnine taken in doses of 1 to 3 mg. a day has been shown gradually to improve visual acuity, sometimes in a matter of days or weeks. Its best effect can be expected in amblyopic patients with central fixation. In fact, satisfactory results have been obtained in mild cases of amblyopia due to anisometropia without squint and retention of good binocular vision. Less satisfactory results have been obtained in cases of squint with eccentric fixation. It seems, therefore, that strychnine either does not act satisfactorily enough on the central scotoma or that it has no effect on the "restoration of normal retinal localization," to speak with the terminology of Cüppers.

BANGERTER'S METHOD

Bangerter makes use of a number of instruments to help attain central fixation and good visual acuity. However, the most important instrument is the pleoptophor devised for the "dazzling and stimulating" method of Bangerter. In using this instrument, while the fixing eye observes a target, the fundus of the amblyopic eye can be observed during the "dazzling and stimulating" procedure. The target over the fixing eye can be made to move into any field of gaze, thus accurately adjusting the amblyopic eye to the most favorable position for the dazzling and stimulating. For the dazzling and the stimulating there are two stencils. One has a central cover to protect the foveal area during the dazzling of the peripheral area. There is a very small central opening through the polarizing filter so that the foveal area is exposed. The foveal area is then "hit" with 40 to 60 light stimulations. The dazzling and the stimulating always precede the exercises performed at the various instruments.

Bangerter also advocates and uses various types of occlusion. He uses complete occlusion of the good eye when there is no fixation; gradual occlusion, meaning the gradual decrease of lens transparency in front of the good eye; and inverse occlusion—occlusion of the amblyopic eye —used in cases of eccentric fixation. He believes that simple pleoptic exercises can be given to children from 3 to 5 years of age (depending upon their mental and psychological development) to correct sensorimotor dis-

turbances. Older children, from 6 to 8 years of age, should be given intensive training, and every effort should be made to complete the treatment during these years. Bangerter feels that in children older than 9 years of age the response to treatment of congenital amblyopia is considerably lessened. However, exercises should be attempted.

One of the first exercises done at the Bangerter school is the localizing exercise for hand and eye coordination. This exercise is done with the fixing eye occluded and follows blinding and stimulation at the pleoptophor. The instrument called the localizer consists of various changeable metal plates with punched-out holes which can be individually illuminated by the examiner. The light points on each metal plate are of various sizes depending upon the degree and distance of the eccentric area. A patient with eccentric fixation will fixate the luminous point with the eccentric area. In order to avoid this, the examiner places the index finger on the light source. The patient directs his attention not to the light point but to the examiner's finger tip. The examiner slowly moves the finger away from the light source and the amblyopic eye is guided away by a passive following movement. When the examiner notes that the light point falls correctly on the cornea, the patient is urged to continue to fix the examiner's finger tip. As the patient is fixating on the examiner's finger, he is asked to cover the light source with his index finger without changing the position of his eye. That is, while the patient is looking at the finger tip of the examiner, the luminous stimulation should fall on the foveal area. The exercise is first performed in a dimly illuminated room, since fixation is steadier under these conditions, then gradually the illumination is increased. The exercise is repeated until hand and eye directions are coordinated correctly. The exercise with the localizer gradually becomes more difficult as the light source is decreased in size and the light can be touched with a pencil instead of the finger. The essential point to remember, when using the localizer, is that the patient's corneal reflex should be constantly observed; if it is not, the exercise with the localizer is of no value. After the patient has mastered the localizer, Bangerter uses the acoustic localizer, corrector and drill. These instruments make use not only of the visual-motor sense but also of the auditory sense. The instruments are built somewhat on the same principle as the localizer.

To eliminate the inhibition present and the agnostic component, Bangerter makes use of various types of mnemoscopes. These instruments coordinate memory and eye by the use of visual impressions on the amblyopic eye, in order to develop central vision.

CÜPPERS' METHOD

The visuscope is used to determine the type of fixation present in the amblyopic eye. The visuscope is a conventional ophthalmoscope modified to allow the image of a small star to be projected and focused on the fundus. The fixing eye is examined first (the contralateral eye is closed during the examination) with low illumination to avoid glare so that the patient can see the star. The examination may or may not be done with a dilated pupil. When the amblyopic eye is examined, the patient should be urged constantly to look directly at the center of the star, even if it is not seen distinctly. The insistence on looking directly at the

center of the star is aimed at obtaining the true sensation of actual vision in daily life. If there is a scotoma present, the patient may use the border of the scotoma in order to fixate the star; upon questioning, he may report that he has the sensation that he is looking past it. Cüppers states that this scotoma in the amblyopic eye occurs more frequently in patients who have worn an occlusion over the fixing eye. If a constant extrafoveal fixation is found, it indicates that occlusion of the fixing eye will probably not be successful.

Cüppers and Bangerter have both reported that if there is a wandering type of fixation, the patient may respond to total occlusion of the good eye. As the eye moves, the image of the visuscope star can be seen to fall on any point from the fovea to the optic disc. This type of fixation appears to be prevalent in patients under 6 years of age. However, this condition may also be found after the amblyopic eye has been occluded for a while. In such cases the occlusion is transferred to the fixing eye. However, frequent follow-up visits are necessary to control the fixation in these cases. When central fixation is obtained, the patient may be seen at less frequent intervals. In a few recent cases, when the visual acuity appears to be at a standstill we have prescribed strychnine pills with good results.

Occlusion of the amblyopic eye, begun about a month or two before pleoptic treatment, is continued during the treatment period. The patient should not be allowed to remove the patch except when undergoing stimulation with the euthyscope. To facilitate the use of the euthyscope, the amblyopic eye should be dilated with homatropine.

The euthyscope, used for producing the afterimage, is an ophthalmoscope containing four discs: a blank disc, a green filter used to locate the macular area, and a third and a fourth disc with a black dot of 3 degrees and 5 degrees, respectively, used to protect the macular area during the stimulation. The fixing eye may be tested first so that the patient understands what is meant by the afterimage and reversion of the afterimage. However, no mention is made of how he should see the afterimage or of the various change of colors he may experience. To produce the afterimage, the patient is instructed to fixate an object at distance with his fixing eye while the green field is projected on the fundus of the amblyopic eye. The lenses of the euthyscope are adjusted until the macular area is clearly seen with the green disc. The green disc is then changed to the disc with either the 3-degree or the 5-degree black dot, depending upon the distance of the eccentric area from the macula. The black dot is placed immediately on the macula and held there for 15 to 25 seconds; the illumination should be as low as possible. As previously mentioned, low illumination is stressed in Cüppers' method in order to avoid creating additional retinal inhibition. After the use of the euthyscope, the fixing eye is occluded and the patient is then seated about one meter away from an intermittently illuminated screen (the intermittent illumination is regulated by an alternoscope). The patient perceives an afterimage which has the subjective quality of an object in space and characterizes the subjective direction of the fovea in space.

During the light phase of the alternoscope, the amblyopic patient may at first see a positive afterimage. This, according to Cüppers, may be due to inhibition, and if the patient

is unable to perceive the reversion of the afterimage (that is, from positive to negative during the light phase), the prognosis is doubtful. The rapidity of the intermittent flashing of the alternoscope will vary with the type of fixation. The stronger the inhibition, the shorter should be the light phase and the longer the dark phase. The duration of the afterimage will vary from five minutes to twenty minutes. Patients with amblyopia and central fixation may report reversion of the afterimage almost immediately. On the other hand, patients with eccentric fixation at first may not be able to appreciate the afterimage or, if they do, it may last for just a few seconds.

When the patient reports that the afterimage has disappeared, the alternoscope may be turned off and the patient instructed to close his eyes tightly in the dark room for at least 20 seconds. When the alternoscope is switched on, the patient may be able to see the afterimage once again. In this way, one stimulation with the euthyscope may last for as long as thirty minutes. A second stimulation is given only when the patient reports that he no longer sees the afterimage even after having closed his eyes for the twenty to thirty seconds.

Thus the first step is reversion of the afterimage, whether the patient has central or eccentric fixation. When the patient with eccentric fixation is able to appreciate the negative afterimage, it should be controlled at all times, for he may see a negative afterimage during one stimulation, but a second stimulation may produce a positive afterimage. Following the reversion of the afterimage from positive to negative, the patient should be made to fix on an object (an *E* or cross) attached to the intermittently illuminated screen and report the position of the negative afterimage in relation to the fixation object. If the afterimage is seen to the right or left of the cross, the patient is encouraged to superimpose the negative afterimage on the fixation object. The time that it takes for the patient to superimpose the negative afterimage on the fixation target will vary. However, Cüppers reports that there are some patients who are able to report the object of fixation at the center of the afterimage when the eye can still be noted in a convergent position. This phenomenon has already been previously mentioned. Such a finding presents a therapeutical problem, since superimposition of the afterimage on the object of fixation may not indicate identical retinal relationship (that is, the fixation object and afterimage seen from the foveal area). As previously mentioned, to determine this type of superimposition, Cüppers advocates use of the "decreasing field test" with the Haidinger brushes.

If, when tested with the decreasing field test, the patient does not report a disappearance of the Haidinger brushes, it can be assumed that he is fixing the target with the foveal area.

The patient may at first report a momentary shifting of the afterimages onto the fixation object and eventually will be able to maintain this superimposition indefinitely. Then, and only then, exercises with the single optotypes should be started. As the patient is able to see even small optotypes, he is allowed to move farther away from the screen. It is important, however, to make sure that the patient sees the afterimage in the center of the optotype. Even the slightest displacement of the afterimage should be discouraged. When

the patient begins to perceive small optotypes at 6 meters away from the intermittently illuminated screen, exercises of hand and eye coordination can be started. These exercises are done with the coordinator (Haidinger brush phenomenon). As previously explained, the coordinator should be used when some form of central fixation, although unsteady, has been restored, or when the eccentric area is very close to the macular area. If the eccentric area is more than 5 degrees from the fovea, the Haidinger brushes may not be seen. If the angle of deviation is large, it is best to correct surgically first so as to make training easier for the patient. The coordinator is a valuable addition to treatment, since it comes closer than the euthyscope to the daily usage of the eyes.

The Haidinger brushes should be first observed with the fixing eye (the contralateral eye is occluded) and then with the amblyopic eye. This is done so that the patient will understand how he should see the brushes. The patient is asked to observe the brushes and to report whether they are always present. It has been noted that some patients will report the disappearance of the brushes during the initial period of training with the coordinator, but this may be due to fatigue. When the patient is able to see the brushes constantly, a fixation object such as the tip of a pencil is used and the patient is instructed to direct the brushes onto the tip of the pencil. The decreasing field test should be used here also to ensure that the brushes and the point of the pencil are seen foveally and that there is not a remanifestation of the old spatial value. Picture slides may be added when the patient is able to maintain the Haidinger brushes on the pencil point. With the Haidinger brushes seen on the pencil point, the patient is instructed to trace the outline of the figure that is on the slide.

When the visual acuity with the single optotypes has reached a normal level, it can be assumed that some form of foveal fixation occurs. However, as has been mentioned, visual acuity when tested with optotypes in a row may show a marked decrease in visual acuity. The patient may report confusion of the letters, the optotypes appearing larger or smaller, or it may be impossible to locate them. As previously mentioned, Cüppers offers the explanation that this may be due to double images that can exist as a consequence of an insufficient change of localization. There is a competition or an overlapping of different visual directions. The eccentric spatial value is still latently persistent and may then become manifest under appropriate conditions. The diplopia could explain the optotype as being greater and the distance between them smaller. To overcome this condition, exercises should be continued with the Haidinger brushes and the afterimage. The Haidinger brushes can also be incorporated in such a way that they can be projected for distance and the patient asked to attempt to place the brushes on the optotypes as they are presented.

To aid the improvement of the visual acuity with letters in a row, we have combined the use of the euthyscope afterimage, alternoscope and Bangerter's "separation trainer." The afterimage is given with the euthyscope, and the patient is seated close to the intermittently illuminated screen. The separator consists of *E*'s of equal size arranged in several rows; the separation between one optotype and another can be decreased to a minimum. The patient is instructed

to place the center of the afterimage on the *E* as the examiner points to the various *E*'s in a row. As the patient recognizes the *E*'s correctly down to the minimum separation, he is placed farther away from the separator.

RESULTS

Before preceeding with the results which we have obtained, a few words should be said concerning testing of visual acuity. The results that will be reported are determined in tenths, according to the system that appears to be commonly used in continental Europe. The visual acuity was always tested according to the scale with the separated *E's* and with *E*'s in a row. It is often difficult to compare the results that have been obtained by various authors, because no mention is made of the distance between the symbols. The results obtained with separated *E*'s may be compared from author to author, but the results obtained with symbols in a row cannot be compared unless the distance is specified. The distance between the *E*'s in a row reported here is equal to one side of the square in which the *E* is inscribed. This was the minimum distance at which clear vision could be maintained for a normal subject, and this distance has been adopted at the Eye Clinic of Rome where I have treated these patients.

To detect the residual degree of amblyopia in one eye, it is quite important to use symbols with a minimum separation. For example, a patient may have equal visual acuity in both eyes when tested with separated *E*'s but may still reveal lower vision in one eye when tested with the *E*'s in a row (provided the distance between the *E*'s is close enough). Furthermore, if the visual acuity is tested with the separated *E*'s or with *E*'s that are too far apart in the row, one may obtain the maximum visual acuity and may therefore believe the patient cured. On the contrary, low visual acuity may still persist when tested with symbols that are close to each other and the tendency for eccentric fixation may still be evident at the visuscope. According to our experience, when the visual acuity is higher than 6/10 with the distance chosen for our optotypes, we can more or less be sure that central fixation has been restored (Bagolini[2,3]).

The visuscopic diagnosis of eccentric fixation presented another problem. To delineate between the various types of fixation is not always easy, as can be seen by the various classifications found in the current literature. To avoid confusion we have sketched the types of fixation and have divided our cases as follows: eccentric fixation when the acquired fixing area was out of the macular area; hesitant fixation when the fixation appeared to shift from the fovea to the macular border; wandering fixation when no fixation was noted; and central fixation when steady foveal fixation was present.

A. Results of Pleoptic Treatment

The results of the pleoptic treatment (table 1 and fig. 2) in 22 amblyopic patients may be summarized as follows.*

According to the diagnostic classification regarding the type of fixation there were 12 cases of eccentric fixation, 5 patients with hesitant fixation,

*The limited number of patients treated was due to the fact that the therapy takes a great deal of time. Our Clinic is not a pleoptic school; therefore, there were other motility problems to deal with. There were other disadvantages, such as the school year and traveling distances that made it impossible for the children to attend the daily sessions. It is also to be noted that not all patients were able to finish their course of treatment.

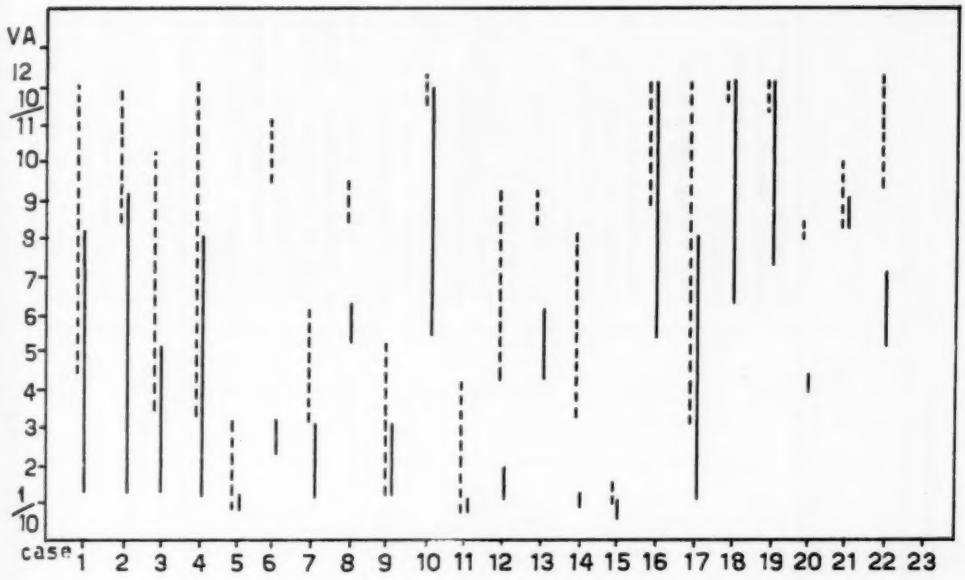

FIGURE 2.*

and 5 with central fixation. In the 12 patients with eccentric fixation, the apparent age at onset was unknown in 3 cases; in the remaining 9, it varied from birth to 5 years of age. In the patients with hesitant fixation, the apparent age at onset was unknown in 3 cases; in the remaining 2, the squint had been present since birth. The apparent age at onset in the patients with central fixation revealed the onset to be from birth to 5 years of age in 3 cases; in the remaining 2, the time of onset was unknown. The ages of these patients varied from 7 to 22 years, and the determination of the refractive error revealed 17 with hyperopia and 5 with myopia. Most of the patients with eccentric fixation had a marked esotropia, and those with central fixation had an amblyopia with no apparent sign of squint, or the amblyopia was due to an anisometropia.

Of the 12 patients with eccentric fixation (table I and fig. 2), 4 developed central fixation (cases 1, 2, 4, 10), one of the patients attained equal visual acuity with single *E*'s and *E*'s in a row. Two of the 12 patients developed hesitant fixation (cases 3 and 8), and the remaining 6 showed no change in fixation, although there was slight improvement of the visual acuity (cases 5, 6, 7, 9, 11, 12). Four of the 6 patients, however, were unable to complete the course of treatment for various reasons. The remaining one (case 7), 21 years of age, had an occlusion of the central artery of the fixing eye. Although the fixation is still eccentric, the visual acuity has improved and the patient is now able to lead a somewhat normal life. She is still undergoing treatment.

Of the 5 patients with hesitant fixation (cases 13 to 17), 2 obtained cen-

*The broken lines on the graphs in figures 2, 3 and 4 represent the visual acuity obtained with isolated *E*'s. The unbroken lines represent the visual acuity obtained with *E*'s in a row. (Before treatment—bottom; after treatment—top.)

TABLE I

RESULTS OF PLEOPTIC EXERCISES (CENTRAL AND ECCENTRIC FIXATION)

NO.	AGE	AGE AT ONSET	RESULTS OF OCCLUSION PRIOR TO PLEOPTICS*		TIME (MONTHS)	PLEOPTICS*		FIXATION	NO. OF SESSIONS	COMMENT
			BEFORE	AFTER		BEFORE	AFTER			
1	16	?				4/10 1/10	12/10 8/10	From E to C	53	No occlusion during pleoptic training. Strychnine with pleoptics; still undergoing treatment
2	10	3 yrs.				8/10 1/10	12/10 9/10	From E to C	47	Still undergoing pleoptic treatment
3	19	3 yrs.				3/10 1/10	10/10 5/10	From E to H	58	No occlusion during pleoptic training. Strychnine with pleoptics; still undergoing treatment
4	12	4 yrs.				3/10 1/10	12/10 8/10	From E to C	83	Treatment suspended; returned to U.S.A.
5	11	2 yrs.				1/50 1/50	3/10 4/50	E Before and after	72	Treatment suspended; school and traveling difficulty
6	18	?				9/10 2/10	11/10 3/10	E Before and after	11	Strychnine prior to pleoptic training. Unable to attend for further treatment
7	21	Birth	Occlusion at 5 years of age		?	3/10 1/10	6/10 3/10	E	123	V.A. 1/50 in fixing eye due to artery occlusion. Treatment on amblyopic eye; still undergoing exercises
8	13	?	6/10 4/10	8/10 5/10	5	8/10 5/10	9/10 6/10	From E to H	44	Cooperation poor, treatment suspended. Strychnine with pleoptics
9	9	4 yrs.	Occlusion at 5 years of age		3	4/50 4/50	5/10 3/10	E Before and after	56	Treatment suspended; poor cooperation
10	14	5 yrs.	Occlusion at 10 years of age		1	12/10 5/10	12/10 12/10	From E to C	35	Treatment stopped Sept. '58; last follow-up visit, May '59; V.A. still equal
11	7	2 yrs.	Occlusion at 4 years of age		6	1/50 1/50	4/10 1/10	E	22	Treatment suspended; poor cooperation

TABLE I (CONTINUED)
RESULTS OF PLEOPTIC EXERCISES (CENTRAL AND ECCENTRIC FIXATION)

NO.	AGE	AGE AT ONSET	RESULTS OF OCCLUSION PRIOR TO PLEOPTICS*		TIME (MONTHS)	PLEOPTICS*		FIXATION	NO. OF SESSIONS	COMMENT
			BEFORE	AFTER		BEFORE	AFTER			
12	22	2 yrs.	Occlusion as a child		?	4/10 1/10	9/10 2/10	E	15	Unable to attend for further treatment
13	12	?	4/10 3/10	8/10 4/10	4	8/10 4/10	9/10 6/10	H Before and after	22	Strychnine and occlusion before pleoptic training; cooperation poor
14	11	Birth				3/10 1/10	8/10 1/10	H	29	Unable to attend for further treatment
15	9	Birth				1/10 3/50	1/10 3/50	H	9	Poor cooperation; treatment suspended
16	11	?				9/10 5/10	12/10 12/10	From H to C	30	Treatment stopped July '58; last follow-up visit, June '59
17	14	?				3/10 1/10	12/10 8/10	From H to C	50	V.A. has not improved beyond 8/10 with E's in a row
18	7	?				11/10 6/10	12/10 12/10	C	18	After treatment stopped, V.A. decreased 2 lines. Given strychnine without occlusion (1.5 mos.); V.A. now equal
19	9	2 yrs.	10/10 6/10	11/10 7/10	9	12/10 7/10	12/10 12/10	C	40	Treatment stopped 3 mos. ago, on last follow-up visit
20	12	5 yrs.	5/10 4/10	8/10 4/10	2	8/10 4/10	8/10 4/10	C	25	Patient as noted improved c occlusion but not c pleoptics; treatment suspended. Given strychnine and occlusion; V.A. now 12/10 and 8/10
21	9	Birth	6/10 5/10	8/10 8/10	3	8/10 8/10	10/10 9/10	C	37	Poor cooperation; also had difficulty attending daily
22	10	?	9/10 5/10	9/10 5/10	1	9/10 5/10	12/10 7/10	C	20	Poor cooperation; treatment suspended

*The visual acuity obtained with isolated E's is recorded first, followed by the vision obtained with E's in a row.

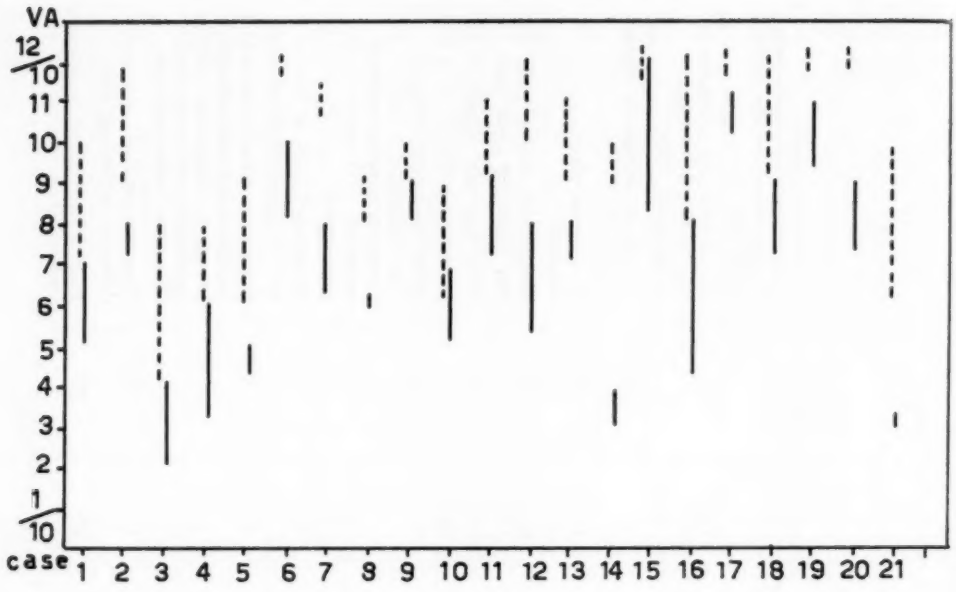

FIGURE 3.

tral fixation. The remaining three still showed hesitant fixation. However, one of these patients was unable to continue with pleoptic treatment because the family was transferred to another country. Treatment was suspended on the other two patients because of poor cooperation.

There were 5 amblyopic patients with central fixation (cases 18 to 22). Two developed normal visual acuity with both isolated and united symbols. Treatment was suspended in two cases because of poor cooperation. The remaining patient showed no improvement with pleoptic training, but the visual acuity has shown some improvement with strychnine therapy and occlusion.

B. Results Obtained with Strychnine

The results obtained with the anti-inhibitory drug, *strychnine* may be summarized as follows: Strychnine pills, 1 mg. taken twice a day, were prescribed to 29 patients (21 had central fixation and 8 had eccentric fixation). The ages of the patients ranged from 6 to 24 years. Of the 21 patients with central fixation, all had an anisometropia (no greater than 3 diopters difference) (table II and fig. 3). During the course of treatment, neither eye was occluded. Examination of the sensorial status revealed binocular vision with some intermittent suppression. At the time that the following results were recorded, the patients had been on a regimen of strychnine from one week to ten months. No ill effects were reported from the use of strychnine except an occasional case of "nervousness." In that case the treatment was suspended. However, in order to avoid such symptoms, the patients were given strychnine pills for three weeks, the drug was suspended for one week, and then the cycle repeated again.

The eight cases of eccentric fixation occurred in patients with convergent strabismus, ranging from a small

TABLE II

RESULTS OF STRYCHNINE ON PATIENTS WITH CENTRAL FIXATION (ANISOMETROPIA)

NO.	AGE	RESULT OF OCCLUSION PRIOR TO STRYCHNINE TREATMENT*		TIME (MONTHS)	RESULTS OF STRYCHNINE*		TIME (MONTHS)	COMMENT
		BEFORE	AFTER		BEFORE	AFTER		
1	24				7/10 5/10	10/10 7/10	2	No occlusion; still on strychnine
2	13				9/10 10/10 7/10 7/10	12/10 12/10 8/10 9/10	4	No occlusion; still on strychnine (bilateral amblyopia)
3	14				4/10 2/10	8/10 4/10	5	No occlusion; treatment suspended, poor cooperation
4	18				6/10 3/10	8/10 6/10	1-2	No occlusion; treatment suspended (nervousness)
5	10				6/10 4/10	9/10 5/10	1	No occlusion; still on strychnine
6	12				12/10 8/10	12/10 10/10	2-3	No occlusion; still on strychnine
7	15				11/10 6/10	11/10 8/10	1	No occlusion; still on strychnine
8	9				8/10 6/10	9/10 6/10	1	No occlusion; still on strychnine
9	6				9/10 8/10	10/10 9/10	0.25	No occlusion; treatment suspended (nervousness)
10	11				6/10 5/10	9/10 7/10	3	No occlusion; treatment suspended
11	11				9/10 7/10	11/10 9/10	1-2	No occlusion; still on strychnine
12	9	8/10 5/10	11/10 9/10	4	10/10 5/10	12/10 8/10	1	Poor cooperation while on occlusion. No occlusion during strychnine treatment

TABLE II (CONTINUED)
RESULTS OF STRYCHNINE ON PATIENTS WITH CENTRAL FIXATION (ANISOMETROPIA)

NO.	AGE	RESULT OF OCCLUSION PRIOR TO STRYCHNINE TREATMENT*		TIME (MONTHS)	RESULTS OF STRYCHNINE*		TIME (MONTHS)	COMMENT
		BEFORE	AFTER		BEFORE	AFTER		
13	6	7/10 4/10	9/10 7/10	15	9/10 7/10	11/10 8/10	1	No occlusion while on strychnine, still on treatment
14	10	2/10 1/10	9/10 3/10	8	9/10 3/10	10/10 4/10	1-2	Prior to occlusion treatment patient appeared to have eccentric fixation; on last follow-up visit the fixation appeared to be hesitant; still on treatment
15	9	9/10 7/10	12/10 8/10	18	12/10 8/10	12/10 11/10	4	Cooperation poor while on occlusion; no occlusion while on strychnine
16	9	5/10 4/10	8/10 4/10	6	8/10 4/10	12/10 8/10	10	Following occlusion the patient had pleoptic exercises; no improvement. Case 20 on pleoptics results. Still on treatment
17	6	12/10 6/10	12/10 12/10		12/10 10/10	12/10 12/10	1-2	Case 18 on pleoptics results. V.A. decreased after pleoptic exercises; given strychnine, no occlusion. Strychnine was suspended 2 months ago; V.A. still equal on last follow-up visit
18	18				9/10 7/10	12/10 9/10	1-2	No occlusion while on strychnine
19	11				12/10 9/10	12/10 12/10	1	No occlusion while on strychnine
20	10	5/10 3/10	12/10 12/10	3	12/10 7/10	12/10 9/10	1	After occlusion had been suspended for one year, the visual acuity was found to be lower with E's in a row. No occlusion while on strychnine; still on treatment
21	8	Occlusion at 4 years of age			6/10 3/10	10/10 3/10	2	No occlusion while on strychnine

*The visual acuity obtained with isolated E's is recorded first, followed by the vision obtained with E's in a row.

esotropia to large angles of squint (table III and fig. 4). Their ages varied from 4 to 19 years. The age at apparent onset was unknown in four cases, and in the remaining four cases the onset occurred between 3 months and 4 years of age. The eyes of three patients had shown no improvement from occlusion before strychnine was prescribed. The de-

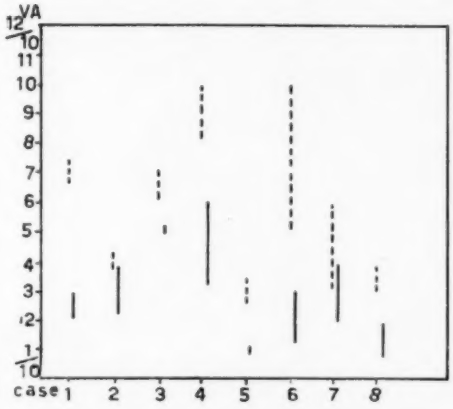

FIGURE 4.

termination of the refractive error revealed two cases of hypermetropia of +5.00 diopters, and the remaining patients had an anisometropia no greater than 3 diopters difference. The patients had been receiving strychnine therapy from two weeks to two months at the time the following statistics were collected. During the course of treatment, occlusion was suspended.

SUMMARY AND CONCLUSIONS

The pleoptic treatment of 22 cases of amblyopia, using mainly Cüppers' technique, and the treatment of 29 cases of amblyopia using strychnine according to the Bietti method lead us to certain conclusions.

Cüppers' treatment not only improved the visual acuity in cases of central, hesitant, or eccentric fixation, but also somewhat improved the fixation. The improvement was frequently quite noticeable when the visual acuity was tested with symbols presented separately. However, the improvement attained a much less significant level when the symbols were presented in a row. The distance between symbols was equal to one side of the square inscribing each symbol.

The fixation could definitely be considered more or less centralized when, with our optotypes in a row, the visual acuity was higher than 6/10. If the visual acuity was maximum with separated symbols, but lower than 6/10 with symbols in a row, the fixation remained hesitant or definitely eccentric when tested with the visuscope.

This evidently indicates that the fixation may be central under certain types of stimulation (especially separated symbols), while with different stimulating conditions it may appear eccentric. In summing up Cüppers' technique, we feel that it may definitely help to improve visual acuity with isolated symbols, but in our experience it failed in most of the cases to overcome that component of amblyopia called "separation difficulty."

Bietti's method of treating amblyopia with the use of strychnine without occlusion gave remarkable results in cases of mild amblyopia without eccentric fixation, and of anisometropia without squint. If there is already maximum visual acuity with separated symbols, the use of strychnine alone may restore full vision with optotypes in a row. Some limited help may be found in amblyopia with eccentric fixation, both with separated symbols and symbols in a row. The use of strychnine with pleoptic ex-

*The visual acuity obtained with isolated E's is recorded first, followed by the visual

TABLE III
STRYCHNINE RESULTS ON PATIENTS WITH ECCENTRIC FIXATION

NO.	AGE	AGE AT ONSET	RESULTS ON V.A. WITH OCCLUSION*		TIME (MONTHS)	RESULTS OF STRYCHNINE*		TIME (MONTHS)	DEVIATION	COMMENT
			BEFORE	AFTER		BEFORE	AFTER			
1	8	3 yrs.	3/10 1/10	7/10 3/10	3	7/10 3/10	7/10 2/10	1	Tropia	No occlusion while on strychnine; refused to wear patch; treatment suspended
2	6	?	2/10 1/10	4/10 2/10	2	4/10 2/10	4/10 2/10	2	Tropia	Occlusion and strychnine; treatment suspended
3	4	3 mos.	1/10 1/10	6/10 4/10	6	6/10 4/10	7/10 4/10	1	Tropia	No occlusion; still on strychnine
4	6	?				8/10 3/10	10/10 6/10	0.5	Small Tropia	Amblyopic eye was occluded for 1 mo. prior to strychnine treatment; fixation shifted from eccentric to hesitant
5	19	3 yrs.				3/10 1/10	3/10 1/10	1	Small Tropia	Following 1 mo. of strychnine, given pleoptic exercises and strychnine; see case 3 on pleoptics chart
6	16	?				5/10 1/10	10/10 3/10	2	Small Tropia	Following 2 mos. of strychnine given pleoptic exercises and strychnine, see case 1 on pleoptic chart
7	16	?				3/10 2/10	6/10 4/10	2	Tropia	No occlusion while on treatment
8	10	4 yrs.				3/10 1/10	4/10 2/10	1	Tropia	No occlusion while on treatment

*The visual acuity obtained with isolated E's is recorded first, followed by the vision obtained with E's in a row.

ercises, or with the conventional occlusion of the fixing eye, seems therefore, to be reasonable.

The results achieved in improving the visual acuity with separated symbols or symbols in a row were so remarkable that they deserve some comment. In fact, in order for reports by various authors to be understood and to be of value, they must include not only the type of test used but also the distance between the symbols. Another important factor that we tend to overlook but which plays a very important role in amblyopia is the illumination of the optotypes. Burian and von Noorden[13] in a recent publication have shown that the visual acuity in amblyopia varies with various illumination according to rules that differ from those pertaining to a normal eye. To report the results only with separated symbols is not justified because the patient may attain maximum visual acuity with this test but still retain poor vision with crowded symbols. Therefore, we may think that we have cured a patient when, in reality, poor vision with eccentric fixation may still exist. In order to be certain that the amblyopia has been eliminated, the visual acuity must be maximum even with symbols in a row, crowded for smaller lines to the limit of discrimination for a normal subject. The above distance between the symbols has proved to be quite satisfactory.

The difference in visual acuity which can be found with separated symbols and symbols in a row, though more remarkable in amblyopia associated with squint, is present also in amblyopia ex anopsia of other origins (such as bilateral anisometropia, high refractive errors, especially hyperopic or astigmatic, and amblyopia ex anopsia associated with organic defects, such as lens opacities of one eye, in which the nature of the lesion does not completely justify the loss of visual acuity). Since the two tests show no important difference in the loss of visual acuity from organic lesions, in doubtful cases the finding of such a difference favors the diagnosis of a functional type of amblyopia. In cases of organic lesions, if there exists a difference between the two tests, revealing an association of a functional and an organic amblyopia, some improvement of visual acuity may be expected with occlusion or pleoptic treatment (Bagolini[3]).

Though I do not have personal experience with Bangerter's pleoptic technique, I did spend some time in Switzerland and became acquainted with both his technique and his theories. One may ask how both Cüppers and Bangerter may obtain good results despite the differences in their theories. From visits to both pleoptics schools, I believe that in spite of the difference in theories, the practical approaches are somewhat similar.

Both men illuminate the fundus, sparing the macular area. Bangerter dazzles the region around the macula, including the eccentric area of fixation. Cüppers also illuminates the fundus around the macula, but with the purpose of provoking an afterimage around the macula; his method differs from Bangerter's in that he purposely avoids strong illumination. Bangerter seeks to reawaken the foveal area by light stimulations, while Cüppers calls attention to the foveal area by making the patient aware of the visual direction of the fovea and the reversion of the afterimage. Bangerter continues the treatment with light stimulation of the macular area by hand and eye coordinating exercises (for example, the *E*'s and

the various mnemoscopes). Cüppers makes use of the Haidinger brushes for hand and eye coordination and, like Bangerter, stimulates the central area with the use of symbols. The practical differences, therefore, do not seem to be fundamental. Bangerter's treatment is more passive and perhaps better suited to a younger age group, while Cüppers' treatment requires participation on the part of the patient.

Apart from the encouraging results obtained by us and others, and also from the limitations that the pleoptic method still presents, there are a few practical questions that may spontaneously arise. When is it expedient to institute pleoptic treatment instead of the classical occlusion of the fixing eye? Are there cases in which conventional occlusion fails and pleoptic exercises do not? Is the occlusion of the amblyopic eye useful in eccentric fixation? What is the relation between pleoptic and orthoptic treatment?

When is it expedient to institute pleoptic treatment? Its best application appears to be in those cases in which little help can be expected from occlusion, or when occlusion must be worn for too long a period. Secondarily, pleoptics may be of more value in patients over 10 to 12 years of age in whom there is a danger that diplopia may be provoked by prolonged occlusion of the fixing eye. Such a possibility seems to be minimized by pleoptics. Finally, pleoptic exercises may be considered the only treatment to attempt for patients with amblyopia ex anopsia with eccentric fixation who have lost the visual acuity of the fixing eye, and in whom a spontaneous recovery of vision may fail or may be extensively delayed.

An affirmative answer can be given to the question: *Are there cases in which conventional occlusion fails and pleoptic exercises do not?* In patients over 6 years of age with eccentric fixation, if occlusion is worn on the fixing eye, failures may be expected. However, good results may be expected below this age. This seems to be the opinion of Bangerter and Cüppers, and our experience confirms it. As is well known, the main objection to occlusion of the good eye in patients with eccentric fixation is the fact that we may further stabilize the fixation of the eccentric area.

Is the occlusion of the amblyopic eye useful in eccentric fixation? Our results are not particularly significant, but it appears that when the amblyopic eye is occluded, the fixation may become more central. Occlusion of the amblyopic eye for a short time is advocated before starting pleoptic training and during pleoptic exercises in order to avoid binocular stimulations which seem to facilitate eccentric fixation. Of course the occlusion should be transferred to the good eye when the fixation becomes central.

Concerning the relation between pleoptics and orthoptic treatment, there are some factors that have to be considered. We tend to believe that it is better to operate before rather than after pleoptic treatment, because of theoretical and practical considerations. According to Cüppers, since the eccentricity of fixation bears a close relation to anomalous correspondence, correcting the squint may also normalize the sensory anomaly; thus a better pleoptic result may be expected.

Furthermore, by improving the vision before surgical intervention, we may facilitate the occurrence of postoperative diplopia, especially in older

patients. If surgical correction is attempted first, we may stop pleoptic exercises at the first sign of diplopia. Finally, the straightening of the eyes may simplify pleoptic exercises, especially in large angles of squint. As regards the possibility of acquiring binocular vision, if we are successful enough to eliminate the eccentric fixation, the prognosis may be favorable if the patient is young enough, though it may be considered poor in older patients.

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VI

SUMMARY

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PLEOPTICS, as has become evident from tonight's papers, is a fascinating new field. Regardless of one's theoretical convictions or of one's opinions about the mechanism of eccentric fixation, or of the seat and nature of strabismic amblyopia, it is clear that the fovea of the amblyopic eye of the patient has to be restored to its position of functional predominance. The main subjective visual direction must be restored to it where it is carried by an extramacular area; it must again become the zero point of the retinomotor values; and one must break through the suppression and the functional scotoma. This holds true, regardless of which one of the deficits in the foveal function is, in the last analysis, responsible for the amblyopia. Experience alone will teach us what is the best method to achieve our goal, or what is the best combination of methods—the use of strychnine or, possibly, of central nervous depressant drugs, the use of scotomization and flashing, or the use of afterimages and Haidinger brushes with their tremendous attention value.

The new methods also raise considerable practical problems. Should all orthoptists be taught the use of the ophthalmoscope? How are we going to cope with the difficulties arising from the necessity of prolonged and intensive treatment?

If the new methods are worthwhile, these problems will find their solution. Certainly there can be no doubt that Bangerter and Cüppers have given a tremendous impetus to the thorough reconsideration of the amblyopia problem and that they have made us even more conscious of our obligation toward this group of patients.

I want to thank our essayists for the devoted and arduous work which they have put into their presentations, making this symposium so successful. Nevertheless, I wish to close with the hope that future generations may not need a symposium on strabismic amblyopia. Let me point out again that we must not lose sight of the fact that amblyopia is largely avoidable, even though a weakness in the *anlage* of the sensory system may predispose to it. *Amblyopia is avoidable.* We should see fewer and fewer intractable cases. Infants and young children from strabismic families should be brought at an early age for examination, regardless of whether they have a manifest deviation. Any child showing a manifest deviation should be brought to an ophthalmologist and adequately treated as soon as a deviation is noted. Let us not forget to spread this gospel in our excitement about the new and powerful weapons against amblyopia which pleoptic methods would seem to offer us.

PLEOPTICS AT THE NEW YORK EYE AND EAR INFIRMARY

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THE Pleoptic Department of The New York Eye and Ear Infirmary has been in existence for about two years, and the purpose of this paper is to report briefly our experience with the methods used, pointing out our successes and our failures.

We follow Cüppers' method, with some minor additions and modifications. The four main tools of this method (visuscope, euthyscope, flicker unit and coordinator) are by now so well known that it appears superfluous to describe them in detail. However, it may not be amiss to give a few hints about the easiest way to handle them.*

In the use of the visuscope we find it advantageous to project the star into the foveal reflex of the amblyopic eye, the other eye being occluded. Only then do we ask the patient: "Do you see a star? Look at it!" In the patient who fixates eccentrically, the foveal reflex will immediately emerge from behind the star and indicate clearly the site of the eccentric fixation; this observation must be made promptly and accurately. If one delays, the observed eye is apt to drift away in a position more comfortable to the patient, who is indifferent to the fact that by this act he gradually loses sight of the star. The observer is thus led to believe that the degree of eccentricity is much greater than it really is.

In the handling of the euthyscope, we never use the polaroid filter, since that would only deprive us of the most important landmark, i.e., the foveal reflex. Nor do we use the lateral switch that changes the focus of the projected beam. This switch is awkward to activate, especially when euthyscoping the right eye. The patient invariably shrinks back when he hears the sharp click and the euthyscope has to be refocused. Therefore, we observe the fundus with the green filter of the horizontal disc of Rekoss, which works smoothly and noiselessly. Rotation of one notch toward the right will give us the 5-degree black shield, and rotation to the left, the 3-degree shield, which is seldom used. Both instruments should be used at low voltage. During the first visit we use the instruments on the good eye as a practical demonstration to the patient of what he is supposed to see with the amblyopic eye.

Incidentally, the double scale with which both instruments are provided is a nuisance. If that feature could be eliminated, it would be a definite advantage.

The flickering unit that regulates the overhead lamp can be substituted by two very simple devices (fig. 1). The first one is very fast. It is inserted between a 75-watt bulb and the socket and flashes more than one hundred times per minute. The sec-

*A pleoptic patient should always have his eyes fully dilated. For diagnosis we use Cyclogyl 0.5 per cent in light-colored irises and 1.0 per cent in dark ones. During the whole treatment we use Atropine 0.5 per cent, one drop daily.

ond one is much slower, flashing sixteen times per minute, and fits into the wall outlet.* Both flashers are used with a silver screen at a distance of about six feet from the patient. This offers an excellent setup for the visualization of the afterimage. Alternation of the two flashers tends to increase the duration of the afterimage.

The patient is told to center the negative afterimage around a target on the screen. In order not to distract the patient's attention by holding or moving the target, we use a dark metal disc which is kept in position in front of the screen by a magnet in back of the screen. The metal disc can thus be moved around freely and the patient's gaze will follow it in a continuous effort to recenter the afterimage. A letter E can be glued to the metal button and then turned in different directions to ascertain that the patient really sees it. The size of the E does not matter as it is used only as a target and not as a visual acuity test (fig. 2).

In the Oculus model of the coordinator it is necessary to reverse the motor in order to change the direction of rotation of Haidinger brushes. We prefer to reverse it by the simple method of placing a piece of ordinary cellophane (e.g., a wrapper from a cigarette package) between the eye of the observer and the coordinator, as in the macula deficiency tester of Goldschmidt. Furthermore, by the use of a camera diaphragm we can progressively decrease the diameter of the field of observation.

We have implemented the basic instruments of Cüppers with two instruments of Bangerter, the corrector and the localizer. Both achieve the reeducation of the amblyopic eye by means of the coordination of reflexes between eye and hand, and eye and ear.

Recently we have added the kaleidoscope to our instrumentation, using it first as a fixation target during euthyscopy and then, after the flash, as an object more apt to capture the attention of the patient than the Maddox cross or the E on the screen (figs. 3 and 4). In this case the macular control is furnished by the ring scotoma caused by the euthyscope that allows the patient to see only with a five-degree central zone.*

In addition to the four basic instruments of Cüppers, we are also using his electronic flash (fig. 5). It is used with a cross-shaped screen when fixation is almost central but unsteady. In many instances it has helped to stabilize fixation and to increase visual acuity when it seemed to have reached a plateau for a number of sessions with the usual instruments.

Pulfrich's phenomenon is used by Cüppers for the diagnosis of fusion in space. A steel ball suspended by a string is made to oscillate on a level with the eyes in a frontal direction. With fixation maintained at a point directly below the ball, midway in the amplitude of its swing, the pendulum will appear to follow a rectilinear pathway.† If a smoked glass is put before one eye, the path of the ball will appear as an ellipse (fig. 6). The apparent rotation will be clockwise when the filter is placed before the

*Both flashers have the advantage of being extremely inexpensive.

*The kaleidoscope and its use will be reported elsewhere in detail.

†Cüppers uses the same pendulum after muscle surgery in order to exercise the eyes and prevent adhesions. It has the same purpose as Bangerter's muscle trainer.

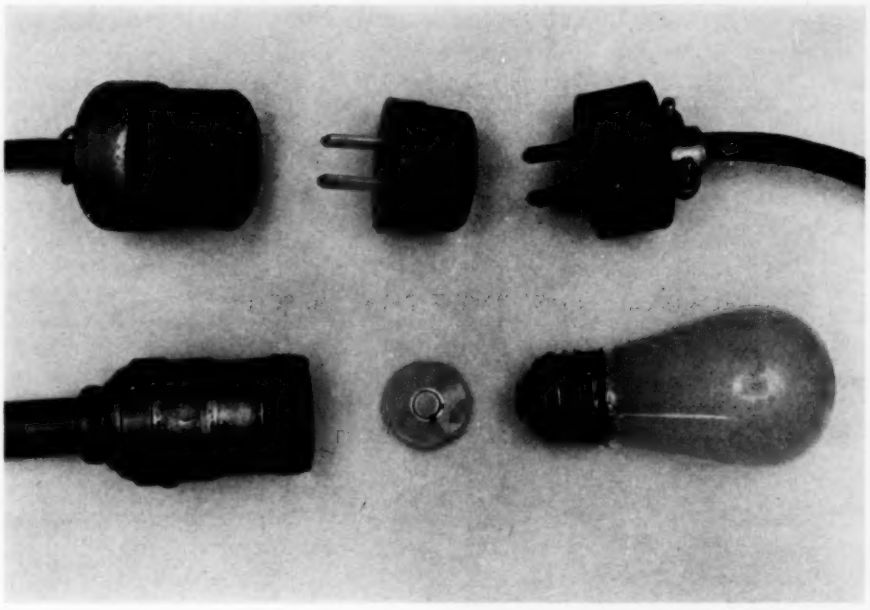

Fig. 1—Flashers.

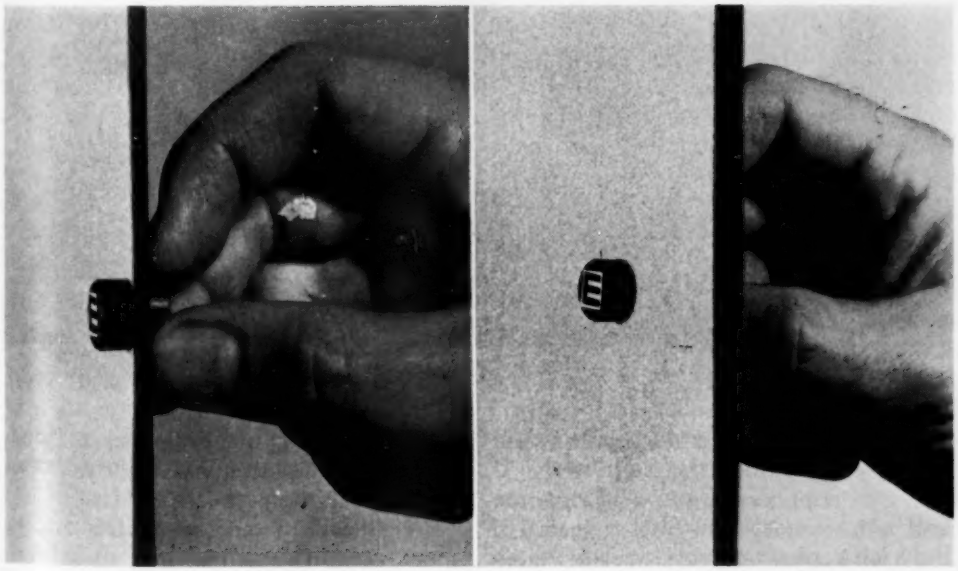

Fig. 2—A metal disc with the letter E on its face is used as a target and is controlled by a magnet behind the screen.

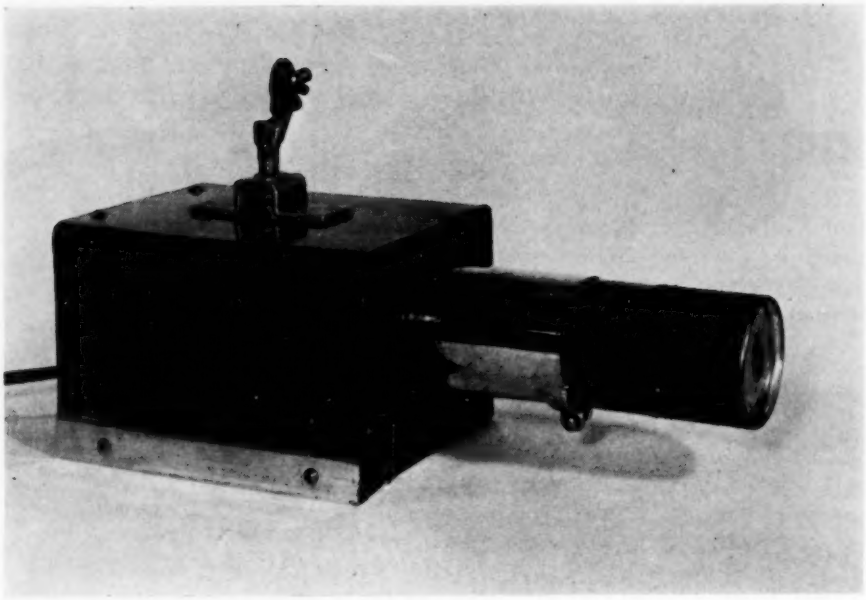

Fig. 3—Kaleidoscope used with euthyscope.

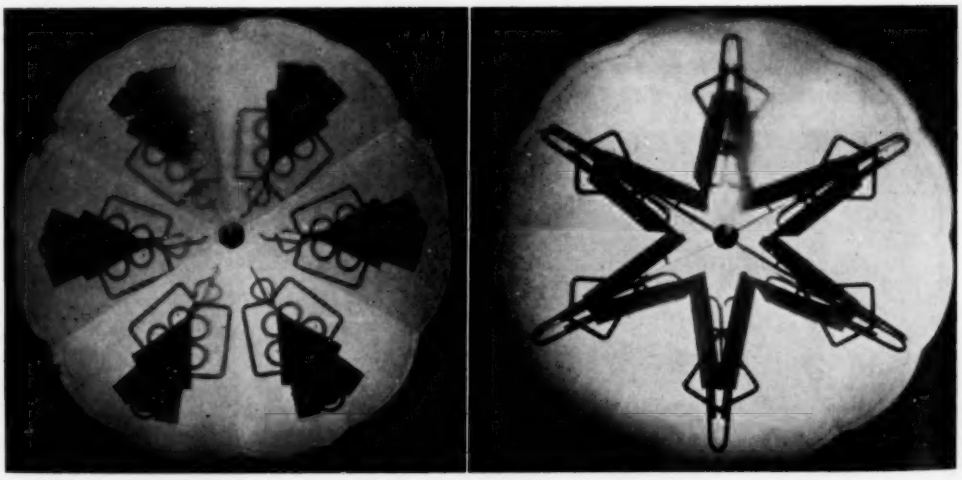

Fig. 4—Kaleidoscopic patterns.

left eye and counterclockwise when it is placed before the right eye. If one eye suppresses, the phenomenon will not be seen. Cüppers says that if Pulfrich's phenomenon is seen when the dark glass is put in front of the amblyopic eye, the prognosis is good. We found that this is a very interesting but not very practical test. Many patients fail to see the elliptic movements of the ball or are unable to describe it. The striated glasses of

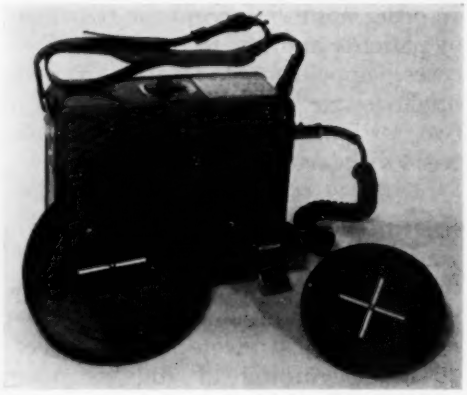

Fig. 5—Cüppers' electronic flash.

Bagolini offer a much simpler and easier way to ascertain fusion in space, as has been reported by Capobianco.

At the very beginning we thought that a careful analysis of the patient's motivation would be useful in the screening of patients, and we divided them into separate groups. (See Priestley et al., October 1959 Journal of Ophthalmology). However, experience has taught us that such a grouping was impractical and artificial and that one had only to consider the candidates, case by case, as one would do for orthoptics or for any other pedagogic problem. The candidate's span of attention, the type and depth of his amblyopia, his willingness to make the necessary sacrifices in terms of time and money will guide us in our advice to the patient for or against pleoptics. It is of interest to recall that Bangerter and Cüppers both warn against rejecting a patient too lightly. Bangerter, especially, is of the opinion that in cases of relative amblyopia (severe organic changes with amblyopia), a serious attempt at pleoptic treatment should be made.

Statistics are a systematic collection and arrangement of numerical facts. In order to draw valid conclusions from these numerical facts the numbers must be large and the facts should be uniform. For these reasons, clinical data are often unsatisfactory. We are well aware of the fact that our pleoptic statistics are at fault on both counts. First, the number of cases is not very large; in the second place, there is lack of uniformity. This second point requires clarification. It is not only the pleoptic cases that lack

Fig. 6—Pulfrich's phenomenon.

uniformity (as is to be expected) but also our methods have varied. In other words, our treatment has undergone constant changes and improvements as our experience with the new methods increases so that a treatment that we would give today is not strictly comparable with what we did one year ago.

Approximately eighty patients came to us as candidates for pleoptic treatment. About thirty did not follow through for various reasons. The results in those who underwent treatment are tabulated in figure 7.

At the beginning of June 1959, due to unavoidable circumstances, there was a considerable reduction in the personnel of our Pleoptic Department.

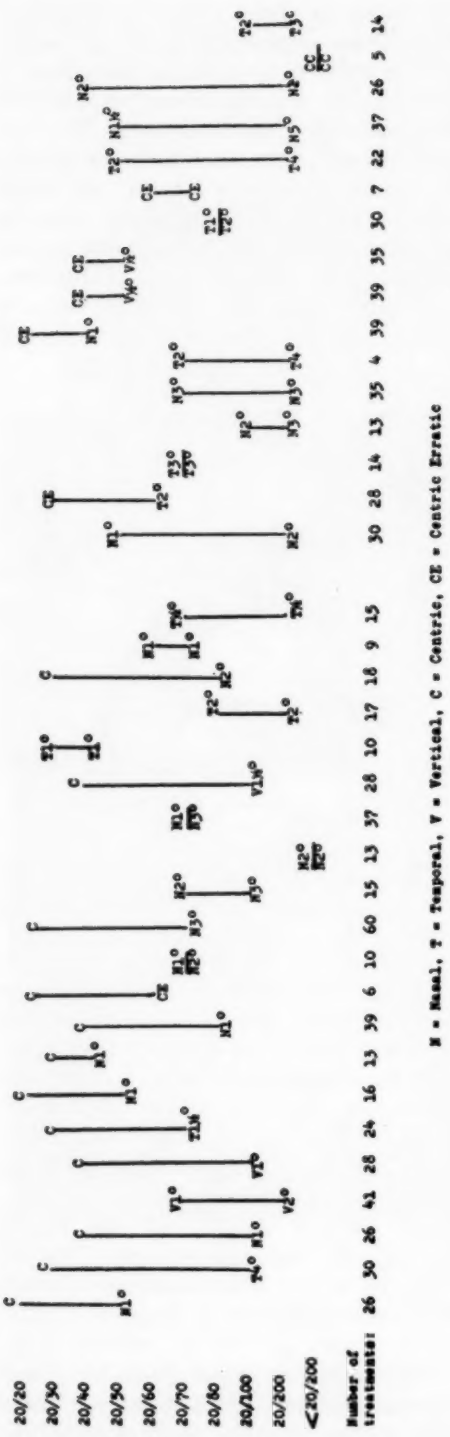

Fig. 7—Results of intensive pleoptic treatment.

In order not to interrupt the treatment of patients and not to turn away new cases, appointments were given at much longer intervals, an average of two sessions a week and the results were disheartening (fig. 8).

I am publishing these results as a warning against compromising with the patients' wishes to give to Pleoptics only a limited amount of time. A patient must devote two full weeks at the beginning of the treatment and considerable time thereafter. To spread the treatment over several months has proved extremely disappointing.

The visual acuity gradient and the degree of eccentricity are so well established that we were led to believe that improvement in the successfully treated patients would follow the identical pattern, i.e., that every degree of progress toward the fovea would be accompanied by a corresponding improvement in visual acuity. Actually, our expectations were not fulfilled in any of our cases. From among our cases I am choosing several with the same visual acuity and different types of eccentric fixation:

Temporal 2°	V = 20/70 —1
Nasal 1°	V = 20/70
Nasal 3°	V = 20/70
Nasal ½°	V = 20/70
Nasal 2°	V = 20/70
Central erratic	V = 20/70

During treatment we found patients in whom visual acuity improved without any corresponding change in fixation, e.g.,

Nasal 2°	V = 20/200
Nasal 2°	V = 20/70

Conversely there were cases showing a shift in fixation without any

improvement in visual acuity, as in the following:

Temporal 2.5° V = 20/200
Temporal 1° V = 20/200

This solution of this riddle is probably to be sought in the presence of scotomas varying in extension and intensity. We believe that in the study of amblyopia and in the interpretation of the vagaries of its behavior, the interest has shifted from the lofty atmosphere of the *Gestaltpsychologie* to the more earthly sphere of the scotomas. This is a very promising field of investigation but very difficult with young patients. Nevertheless, it is being explored now in the clinics of Giessen and Rome.

In the therapeutic attack on the scotoma, it is immaterial whether it is dissipated by frontal attack, like in Bangerter's method, or from the rear, like in Cüpper's method, in which the *will* to see can assert itself only in the island of light surrounded by the wide ring of darkness. Common to both methods is the effort to re-establish central fixation as the first step, while the ultimate aim is to restore to the fovea its proper rank and local sign.

It is not easy to give definite rules for the treatment of amblyopia. The following is only an approximate outline.

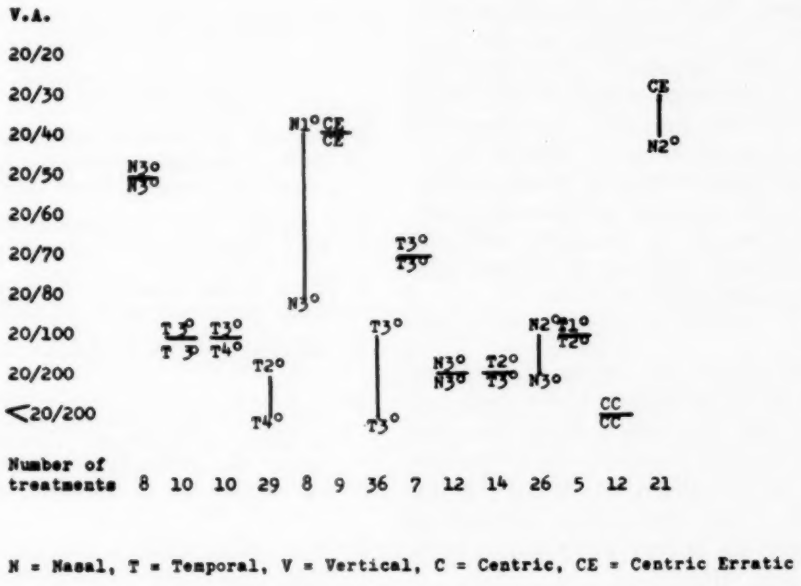

Fig. 8—Results of spaced pleoptic treatment.

As soon as the diagnosis of amblyopia is established, the affected eye is occluded for four weeks and then treatment is started. At the beginning it must be intensive. We advise two daily sessions of not less than one hour each. If no improvement is obtained during this period of time, the patient is discharged. If improvement is registered, it is permissible to relent a little, but not less than one treatment a day should be the rule.

When the amblyopic eye has reached a visual acuity of 20/50 or better

(single letters), orthoptic treatment is started, or surgical correction made if indicated. If fixation is central or nearly central, occlusion is shifted to the good eye. To consolidate the therapeutic gains, home exercises at the coordinator should be continued daily for at least three months*

Burian has stated, with excellent reasons, that amblyopia is a disease of neglect. With adequate and prompt medical care, amblyopia can be prevented. Thus the doubt arises whether it is worthwhile to engage in the study of a treatment that may soon have no practical application. I believe, however, that unfortunately there will always be a number of patients that, for one reason or another, will not have medical care in time and will develop amblyopia.

Furthermore, according to the most conservative statistics, about two per cent of the population have one amblyopic eye. Therefore, there must be about three million amblyopes in the United States, and this number is large enough to keep pleopticians busy for a long, long time.

SUMMARY

1. Practical suggestions are offered for the use of pleoptic instruments.
2. The kaleidoscope is added to the list of pleoptic tools.
3. Tabulations and statistical considerations are presented from which a clearcut warning emerges against spacing the treatments too far apart. Pleoptic treatment, unless intensive, is useless.
4. Eccentricity and visual acuity do not run parallel.
5. Pleoptics has a future.

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*At Professor Cüppers' Institute, coordinators are rented to the patients.

I am indebted to our chief orthoptic technician, Miss Jane Romanio, to the students, Miss Linda Wright and Miss Feiwelson, and to Drs. Safir, Byron and Weseley for their work in the Pleoptic Department.

HORROR FUSIONIS

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BECAUSE cases of horror fusionis are rare, less has been said about it in the literature than about any other form of defective binocular vision. Bielschowsky, von Graefe, Duane and Burian have defined it for us as clearly as it can be described. They have put up the "storm warnings" regarding this grave anomaly; but these warnings have at times gone unheeded, or they have been confused with the condition of paradoxical diplopia by the surgeon and the orthoptist. Since the orthoptist is largely responsible for an analysis of the state of fusion prior to surgical intervention, this paper is offered merely as a reminder to be ever watchful for cases of horror fusionis, rather than as a report of anything new on the subject.

Bielschowsky[1] stated that horror fusionis may be due to a defective development of the sensorial apparatus in the occipital lobes. In such cases it would be congenital and therefore, one assumes, incurable. However, he further states that it may be produced by a protracted disuse of one eye or may arise because of a severe nervous shock, and that the fusion faculty may be capable of being developed by proper training and a most careful removal of anything that may cause a difference between the visual functions of both eyes. I take this to mean correction of refraction, anisometropia, aniseikonia, amblyopia and strabismus. In this instance, one wonders whether he implied that the disturbance in the fusion faculty would have to occur in infancy before the fusion apparatus had been sufficiently stimulated towards the goal of binocular single vision, or whether he means that the binocular reflexes could be well on the road to maturity before the incidence of shock, which arrested the fusional development.

Burian[2] defines horror fusionis as an active aversion to fusion. Since the chief symptom is constant diplopia, it might be considered that there is also an active aversion to suppression. The patient is unable to suppress. If the angle of squint is large enough to permit wide separation of the images and if he is an emotionally stable person, he may be able to live with it without discomfort. If the images are close together, it is impossible to ignore the diplopia entirely; hence, surgical correction of a strabismus is indeed a dangerous procedure.

As Burian has shown in several papers on the subject, it is very easy to confuse postoperative paradoxical diplopia with horror fusionis. They are entirely different anomalies. In fact, when I undertook to write this paper for presentation before this Association, I thought I had thirteen cases, collected over a period of twenty years, under the classification of horror fusionis. After careful study of these case reports, and after reexamination of two of the patients recently, I found that the diagnosis had been incorrect in eight cases: seven were definitely cases of paradoxical diplopia with anomalous cor-

respondence existing at some time during life, and one was really only a case of very weak fusion with normal correspondence which closely simulated horror fusionis. After a review of the literature, I felt justified in calling only five cases *horror fusionis*.

Burian and Capobianco[3] have given us the differential diagnosis between the two anomalies. In horror fusionis, images fall on corresponding points but are not seen singly. There is no acceptance of bifoveal stimulation or peripheral stimulation. In my small series of cases, the correspondence was normal in all cases on the major amblyoscope. With the afterimage test, three showed normal correspondence and two showed an alternation of the images in the same place and some general confusion, but not anomalous correspondence. I stress this factor, because if you see a patient who cannot fuse and who has or has had abnormal correspondence at any time, you will appreciate that there has been some desire and effort on his part to attain fusion. If he has the desire to use the fusion faculty and tries to use it, even in an abnormal fashion, then it is only logical to assume that he has no horror of fusion. Therefore, one can assume that this patient has an interesting case of paradoxical diplopia, often with triplopia, and that he may be using both anomalous and normal correspondence. In horror fusionis, insistence on the part of the examiner that the patient try to fuse may produce disagreeable symptoms, the intensity of which will be commensurate with the emotional stability of the patient.

The second important characteristic of horror fusionis is that there are always slight fusional movements at the objective angle. These can be seen when the major amblyoscope is used, more dramatically than with the double-image test, although the latter test is very revealing. These movements are more easily interpreted on the major amblyoscope, particularly in young children. Using macular simultaneous perception or fusion slides, ascertain the objective angle of the squint. Set the arms at this point, and it will be found that the images almost touch each other but never fuse. The movements of the eyes at the objective angle never stop, in active avoidance of fusion. The images may overlap horizontally, jump up and down vertically, jump over each other entirely, or merely slide through each other to separate by only a few diopters. When the separation of the images is increased by the examiner, the eyes become quiet and the patient begins to relax. The images are then separated widely, to the limits of gaze on the instrument. It will be noted that the patient always maintains diplopia and never suppresses, whether the images are on the convergent or divergent side of the objective angle. Now bring the moving target toward the stationary one and the eye will move quietly with it until the images are between two and four prism diopters from the objective angle of squint. Immediately the characteristic movements of horror fusionis will be reinstated as the bifoveal region is reached. In three of my patients, nausea and headache were produced the moment the bifoveal region was reached and they became tense and nervous.

The same technique of examination should be followed using peripheral slides, and finally Stark red-green slides to see whether there is any mixing of colors. The patients may give misleading answers at times, saying they think they "fused momen-

tarily." My experience has been that some patients, knowing their eyes are abnormal, try to pretend to themselves for brief moments that they are capable of performing a normal binocular act. This "whistling in the dark" attitude can always be judged by the observer on the basis of the typical movements of the eye and subsequent examinations, particularly in children. If the eyes are still in motion at the objective angle when the patient says he thinks they may be fused, then he is probably not fusing. If, on the other hand, all motion stops and the eyes appear to be at rest and if he can hold his fusion at the exact angle of the squint, then he does not have horror fusionis. He probably has just a weak fusion sense that has never been sufficiently stimulated.

The third point to remember is that the patient with horror fusionis never has monocular diplopia; therefore, triplopia cannot exist. In monocular diplopia, the constant diplopia of which the patient complains is due to the fact that he has anomalous correspondence persisting after the angle of squint was changed, generally by surgical intervention, and that his two foveas maintain the two different visual directions which they had prior to operation. I recently saw a case in an adult who had never had an eye operation, although most cases of paradoxical diplopia occur after some surgical procedure. This man had complained of constant diplopia for twenty years. He was a high hyperope who had worn glasses since he was two years old for a convergent strabismus. The glasses apparently kept his eyes straight for some years because his squint was purely accommodative. He gradually developed a small mechanical factor, apparently because the power of his lenses was reduced too much, and anomalous correspondence developed. After this habit was established, another ophthalmologist put back the full correction. This pushed the angle of squint almost to orthophoria, or changed it so that the patient was forced to seek for his anomalous correspondence on the exotropic side. His eyes gradually became divergent. When I saw him, triplopia could be elicited easily on the synoptophore. The afterimage test gave an anomalous response, but he had symptoms similar to those we see in other cases postoperatively. I am intrigued with the comparison of these two kinds of anomalous vision because they both have an aversion to suppression and both suffer the disturbing consequences of diplopia.

Case 1. W. F. age 18, male, had a history of onset of squint at age 4. He could not be sure in retrospect whether it was convergent or divergent but felt sure that "he was wall-eyed." He had been given orthoptic training in four different cities. This had allegedly corrected the deviation, but he could not get rid of his diplopia. At age 14 he had had a bilateral operation, but since the surgical scars had healed well, it was not possible for me to tell whether it was performed on the lateral or medial rectus muscles, and he could not remember. Since the operation, the diplopia had become worse because the images overlapped but never fused perfectly. Print was always double. He was emmetropic and the vision was 20/20 each eye. Prism and cover test showed an exotropia of 20 prism diopters for near and 10 prism diopters for distance. Worth dot test showed crossed diplopia for distance and near, the separation of the images corresponding approximately with the angle of deviation. The ocular rotations were normal. The near point of convergence was at 5 cm. On the synoptophore the objective angle was 10 prism diopters of exotropia for distance. Subjectively there was no simultaneous perception or fusion. The images jumped over each other around the objective angle. There was no suppression of either eye. Print slides were double. His near reading objectively was exotropia 4, lower than the prism and cover measurements. This probably could be explained by the fact that he had a good proximal convergence and the −3.00 sphere lenses used on

the synoptophore stimulated an accommodative-convergence movement. The same behavior of the images at the objective angle was present, with no fusion. No monocular diplopia could be elicited, since the correspondence was normal. On the afterimage test he appeared to alternate, the images appearing in the same place. An attempt to stimulate his fusion on the synoptophore was unsuccessful. Since he appeared to have horror fusionis, with typical fusional movements at the objective angle, treatment was contraindicated. It was suggested that he occlude one eye during the summer months in order to study for his examinations and also to learn to ignore one image when the occlusion was removed. He could alternate at will and had learned to do this rapidly because, by switching constantly, his diplopia was less noticeable to him, although always present.

Case 2. F. G. age 27, male, stated that he had had trouble with his eyes since childhood, not only because of myopia but also because of constant diplopia. He was not examined until age 6. No treatment other than glasses was given. The diplopia made him very belligerent; he did poorly in school and could never get along with people. He went into the Army and was discharged as unfit for duty. At the age of 25 he began orthoptic training in another city. He persisted for two years but could never fuse. He had constant headache. He was examined for aniseikonia during this period but the results were negative. At the time I saw him he was taking tranquillizers and thyroid extract, which he said made him a little more agreeable. His refraction was O.D. −5.25 sph. −0.75 cx 165, 20/20, O.S. −5.50 sph. −1.00 cx 160, 20/20. The prism and cover test showed 0 with left hyperphoria 8 for distance and exotropia 4 with left hyperphoria 4 for near. The dark red glass test showed that the left hyperphoria was probably a dissociated vertical divergence due to the lack of fusion. Ocular motility was normal, except for a very slight overaction of the left inferior oblique and an equally slight overaction of the left superior rectus, so slight that it was not considered significant, particularly since he insisted that his diplopia was always horizontal and on a level. On the synoptophore the objective angle was esotropia 2 with no hyperphoria. Subjectively, images jumped over each other at the objective angle. He could find no subjective angle at which he could fuse. At the objective angle sometimes there was excyclotropia of 8 diopters in the right eye with left hyperphoria of 2, but this would disappear the moment correction for it was instituted on the instrument. Images almost fused, then slipped through each other. There were active movements of the eyes at the objective angle which were not present until the bifoveal region was reached. The afterimage test showed that the images would alternate in the same place. He described a "pulling apart and coming together" motion at times when he thought he saw them simultaneously. Although his answers were confused, I could not interpret them to mean anomalous correspondence. The patient was belligerent and emotionally disturbed and was difficult to examine. He felt that an operation would cure him and resented the fact that no one would operate on him. The ophthalmologist in charge of the case at this time had told him it would not help. When I told him orthoptic training was risky and might make his diplopia worse, he stated that suicide would probably be his only release from diplopia. In this case, surgical intervention to give him a strabismus and separate the images either vertically or horizontally was too fraught with danger because of his emotional instability. He would still have had the diplopia, I believe.

Case 3. Mrs. J. R. age 33, housewife with two children, had had a convergent strabismus since birth. She wore glasses at the age of 2. The squint was not noticeable after that so she had never had surgical correction. She had experienced constant diplopia since she was a small child but had learned to live with it, since she was incapable of suppression. She was sent to me for examination only because she was taking a secretarial position and thought that new developments in the study of vision might offer her some help for the diplopia. She had had orthoptic training at the age of 14 which did no good. A vertical prism was incorporated in her glasses when she was in college, but it bothered her and made the diplopia more annoying, since it leveled the images and brought them closer together and she could not fuse them. Her refraction was O.D. +0.50 +0.50 cx 85, 20/100, O.S. +0.75 +0.25 cx 100, 20/20. Prism and cover test with or without glasses revealed no horizontal or vertical deviation; there was no movement of the eyes at all. The ocular rotations were normal. The Maddox rod test showed X 8 with L.H. 2 for distance and X 2 with L.H. 1 for near, but this was merely an approximation as the line and light kept jumping back and forth in constant movement.

On the synoptophore the objective angle was X 2 with L.H. 4. Subjectively the images

jumped over or slipped through at the objective angle. There was no attempt made to attain anomalous correspondence. There was no suppression of either eye, not even of the amblyopic right eye. Typical movements of aversion to fusion around the objective angle were present on foveal, macular or peripheral slides. Print was double.

The afterimage test showed normal correspondence. With her head tipped to the right, fixating at 6 meters and a red glass before either eye alternately, there was left hyperphoria 3, head tipped to the left there was left hyperphoria 4. It was thought that perhaps the hyperphoria might be responsible for the diplopia. A prism of 3 base down over the left eye was tried. This kept images level in the primary position but they would not fuse and the eyes were in constant motion. Since there did not seem to be much variation in the amount of the left hyperphoria, it was hoped that correction of it might stimulate her fusion but the rejection was the same as it had been when it was tried during her college days some fifteen years ago. Since she had adapted herself so well to the diplopia and, fortunately, had an amblyopic right eye that dimmed the second image still more, treatment was contraindicated. She was a stable person and accepted the diagnosis of horror fusionis with grace.

Case 4. J. A. age 17 years, male. This young man had a history of diplopia following a brain concussion at the age of 6. This case falls into the category which Bielschowsky described as arising from a severe nervous shock. At about the age of 14, eight years after the brain concussion, the diplopia became constant. Results of physical examination was negative. He had never worn glasses. He had been given orthoptic training by an optometrist for two and a half years between the ages of 7 and 9.5 years, but stated that he could never fuse more than momentarily. When I saw him the vision in the right eye was 20/30-1 and in the left eye 20/20-1. Prism and cover test revealed an exotropia of 20 prism diopters for distance and 12 prism diopters for near. The rotations were normal. The Worth four dot test showed crossed diplopia corresponding to the angle of squint. The afterimage test revealed normal correspondence. On the synoptophore the objective angle was exotropia 20 for distance and near. Subjectively, images drifted back and forth at the objective angle but would not fuse. There were typical movements of aversion to fusion at the bifoveal region. He stated that ordinarily he could "see through" one image which he knew to be the image seen with the nonfixing eye. He was fairly well adjusted to the situation and was keeping up with his high school studies as an average student. He was told that surgical intervention and orthoptic training were contraindicated and that it was best for him to try to live with the situation. We felt he could do this as he was a very reasonable person.

Case 5. Age 7.5 years, female. This is the only case of true horror fusionis I have encountered in a child. There was a history of exotropia intermittently since infancy. She had always noticed diplopia but the parents ignored it, thinking it was her imagination. The vision was 20/20 in each eye and her refraction showed a slight amount of hyperopia, for which glasses were not given. The prism and cover test revealed an exotropia of 30 prism diopters for distance and 25 prism diopters for near. The Worth dot test showed crossed diplopia for distance and confusion for near. The ocular rotations were normal. The near point of convergence was at 2 cm. The eyes looked straight much of the time, but there was no prism convergence at either distance or near. On the synoptophore the objective angle was exotropia 30, right hyperphoria 4 for distance and exotropia 30, right hyperphoria 2 for near. There was no attempt at anomalous correspondence. Upon oscillation of large peripheral stimuli at the objective angle, she reported that they seemed to fuse momentarily on her first visit, but she was never sure. Foveal and macular slides showed the characteristic jumping over and drifting back and forth at the objective angle. The afterimage test showed normal correspondence.

Because of her age it was decided to give this child orthoptic training, since we felt that this might prove to be merely a case of weak fusion that needed stimulation. At the end of one month of training in the office plus daily home exercises of every kind and description, which she carried out faithfully, it was decided that this was a case of horror fusionis. She could not fuse under any conditions; the movements of the eyes at the exact angle of squint were an avoidance of fusion. Care was taken during the treatments to minimize the diplopia and to try to get her mind away from it when not doing exercises. The parents were instructed not to mention diplopia to her, since it was obvious that the daily orthoptic training, without result, might introduce psychosomatic symptoms. She was then given a two months' rest from treatment with instructions again to the parents to say

nothing about her eyes, except assurance that we were pleased with her progress, should the subject be mentioned by her. The ophthalmologist in charge of the case wisely felt that surgical intervention should be avoided. Two months later, upon re-examination, the situation remained unchanged. Two years later, not having seen the child, I telephoned the mother on the pretext of talking with the child, who was then 10 years old. Upon questioning her in as subtle a way as I could manage, she reported diplopia whenever she thought about it but it did not bother her and it was spontaneously present only occasionally. Since the angle of the exotropia was 30 prism diopters for distance and 25 prism diopters for near, the second image was far enough away for her to ignore it.

Although horror fusionis is infrequently encountered, it is important that patients with this form of insuperable diplopia be properly diagnosed. Orthoptic treatment should not be attempted. This paper has been especially directed to the orthoptist who seldom has the opportunity of seeing older patients, but who may still be able to make the differential diagnosis between horror fusionis, monocular diplopia in cases of weak fusion.

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TWO NEW OPTICAL INSTRUMENTS: BINOCULAR TRAINER AND PHYSIOLOGIC DIPLOPIA READER

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ATLANTA, GEORGIA

Binocular Trainer

THE Binocular Trainer was designed for use by the patient, by the orthoptist, and by the ophthalmologist who does not have the services of an orthoptist. It is both diagnostic and therapeutic. The doctor or the orthoptist can diagnose the sensory anomaly and the treatment may be safely carried out at home by the patient.

This instrument was developed because of the inadequacies of available home instruments—the stereoscope, purely subjective and with no controls; the tracograph, with no scale and clumsy to use; and the Pigeon Cantonnet, a flimsy structure.

The principal uses are presented herein, although it will be obvious to the trained reader that its flexibility and ease of use lend themselves to other areas of exercises and training.

PRINCIPAL USES

I. Diagnosing abnormal retinal correspondence

II. Treating abnormal retinal correspondence both at home and at the office

III. Breaking all types of suppression

IV. Developing vergence amplitudes

If a vertical condition is present, all the above exercises can be carried out.

I wish to acknowledge Mr. Arnold E. Hardy, engineer, who made the first model to my specifications and contributed greatly to its design.

Binocular Trainer.

INSTRUCTIONS

I. *Diagnosing Abnormal Retinal Correspondence*

A. Do a prism and cover measurement at thirteen inches. This is the objective angle. Example: Esotropia twenty diopters.

B. Tilt the instrument to the side and forward so that the patient will look into the mirror with his nonpreferred eye. Do not tilt the head to the side. The visual line should be perpendicular to the table on which the instrument sits. For example, the patient with a left esotropia would look in the mirror with his left eye (fig. 1). The bridge of the nose

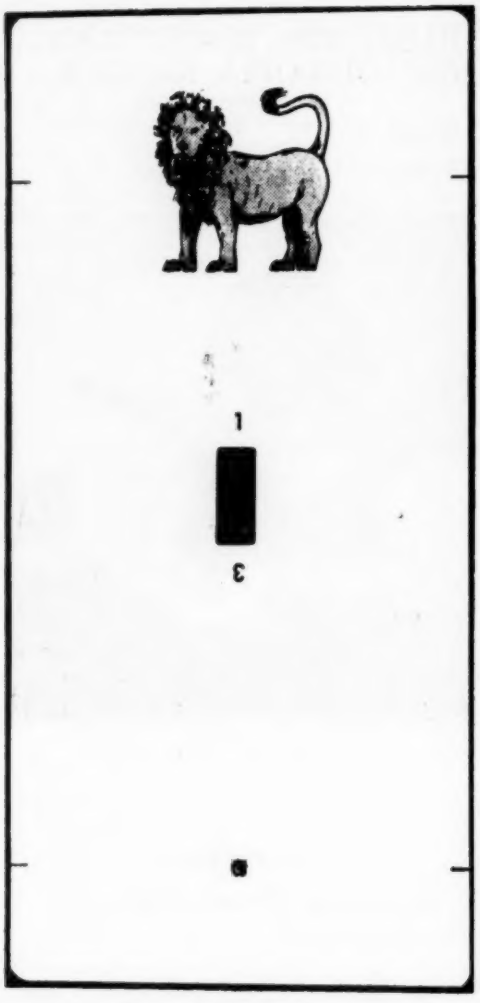

FIGURE 1.

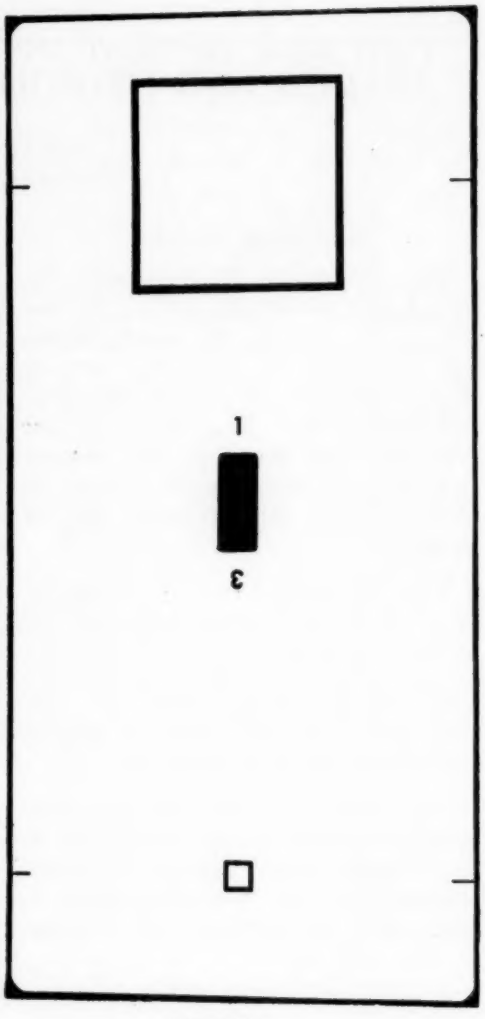

FIGURE 1,a.

should be against the curved part of the septum.

C. Use dissimilar pictures, or first grade fusion targets. Place the lion (fig. 1) on the chart of the wingboard where it will be seen in the mirror with the nonpreferred eye. Be sure the reference marks are in alignment with the two zeros. As in the case of a left esotropia, the left eye sees the lion in the mirror.

D. Place the lion's cage (fig. 1,a) on the chart of the opposite wingboard where the preferred eye will see it. This eye does not look into the mirror.

E. When the patient sees both the lion and the cage, ask him to slide the lion's cage along until he sees the lion in the cage.

FIGURE 2.

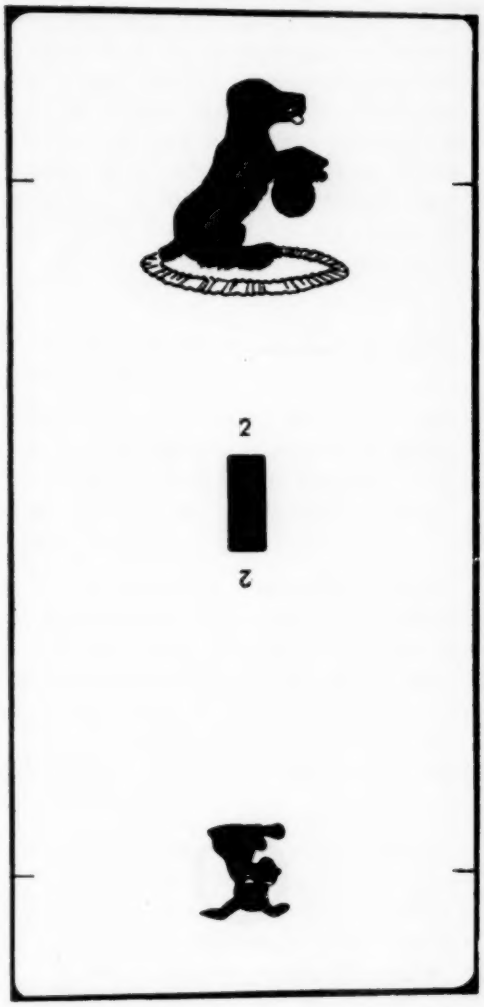

FIGURE 3.

FIGURE 2,a.

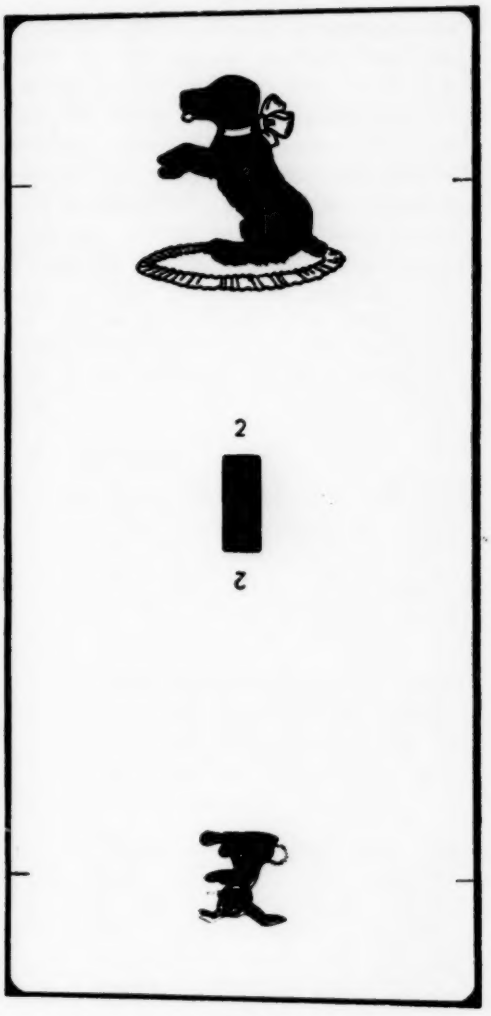

FIGURE 3,a.

F. Note on the scale the position where he reports that the lion and the cage are superimposed. This is his subjective angle.

G. If normal retinal correspondence is present, he will superimpose within five diopters of the prism and cover measurement at thirteen inches. That is, if the prism and cover measurement is twenty diopters base out, he will superimpose on the wing-board within five diopters of twenty diopters on the convergent side of zero. The objective and subjective angles are the same. If abnormal retinal correspondence is present, he will superimpose at an angle less than twenty diopters on the convergent side. The subjective angle is less than the objective angle. However, be sure to allow a margin of five diopters be-

FIGURE 4.

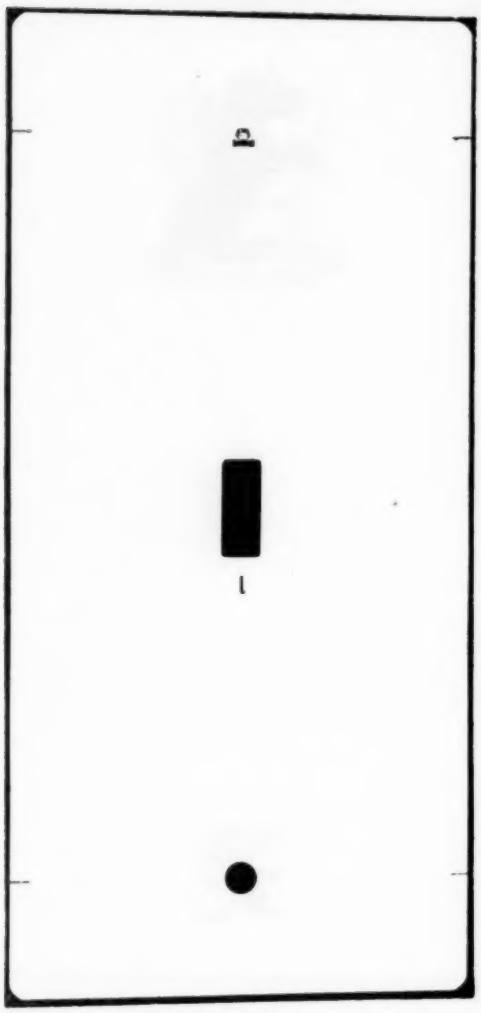

FIGURE 5.

FIGURE 4,a.

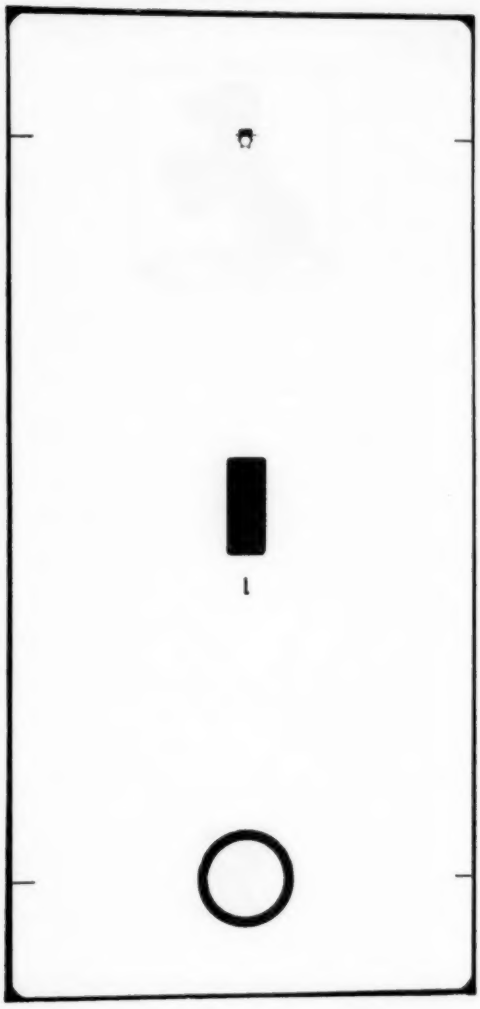

FIGURE 5,a.

fore calling it abnormal retinal correspondence.

H. To test for second grade fusion, repeat exactly the above procedure using similar pictures, such as the dogs (figs. 2 and 2,a, peripheral fusion). If normal retinal correspondence is present, the patient will fuse the dogs within five diopters of the objective angle. To determine suppression toward and including the fovea, repeat the procedure with the rabbit (figs. 3 and 3,a) and the little clown pictures (figs. 4 and 4,a). Be sure the patient reports seeing both control marks simultaneously; for instance, the hat and the tie on the clown.

I. After fusion is demonstrated, convergence amplitude may be mea-

sured by moving the object not seen in the mirror on the convergent side in until diplopia is appreciated. Divergence amplitude is measured by moving the object out on the divergent side to the point where diplopia is appreciated. (If suppression from amblyopia is too deep, the vision may have to be improved by occlusion of the good eye before the above test can be achieved.)

II. *Treatment of Abnormal Retinal Correspondence*

This treatment may be safely carried out at home, consequently progress is much faster. In addition, this saves the patient office visits and expense.

A. In treating abnormal retinal correspondence, one must be aware of certain cases which do not as a rule respond well to treatment. These are:

1. Deep amblyopia which is not correctible.
2. Harmonious abnormal correspondence (the subjective angle is from zero to five diopters base out, that is, the angle of anomaly is equal to the angle of squint. For example, the subjective is at zero and the objective angle is at twenty base out). When harmonious abnormal retinal correspondence is demonstrated on the following tests, the prognosis is poor.
   a. Afterimage (positive and negative)
   b. Double image
   c. Haplascopic instrument (binocular trainer, amblyoscope)
3. Alternators

B. Children who can successfully perform the following exercises may vary in age. Some mature four and one-half year olds or five year olds, can do fairly well. If amblyopia is present, constant occlusion should be carried out until the best possible vision is obtained. When the vision in each eye is equal or almost equal, treatment for abnormal retinal correspondence should be started. Total occlusion should be continued throughout the course of treatment and up to the time of surgical operation.

1. Technique
   a. Place the number 1 sized ball (fig. 5) in alignment with the zeros on the wingboard to the side where the nonpreferred eye will see it in the mirror.
   b. Place the number 1 sized circle (fig. 5,a) on the wingboard to the opposite side of the septum where the preferred eye will see it.
   c. When the patient sees the ball and the circle simultaneously, instruct him to place the circle so that he sees the ball on the right side and the circle on the left side.
   d. While he maintains constant fixation on the ball, instruct him to keep the circle as close to the ball as possible while he moves it from the right side to the left side of the ball. At first the ball may disappear as the circle moves across it, but after a while, as suppression breaks, he should begin to see the ball in the circle as the circle crosses it. The movement across should be fairly rapid. Be sure that constant fixation

FIGURE 6.

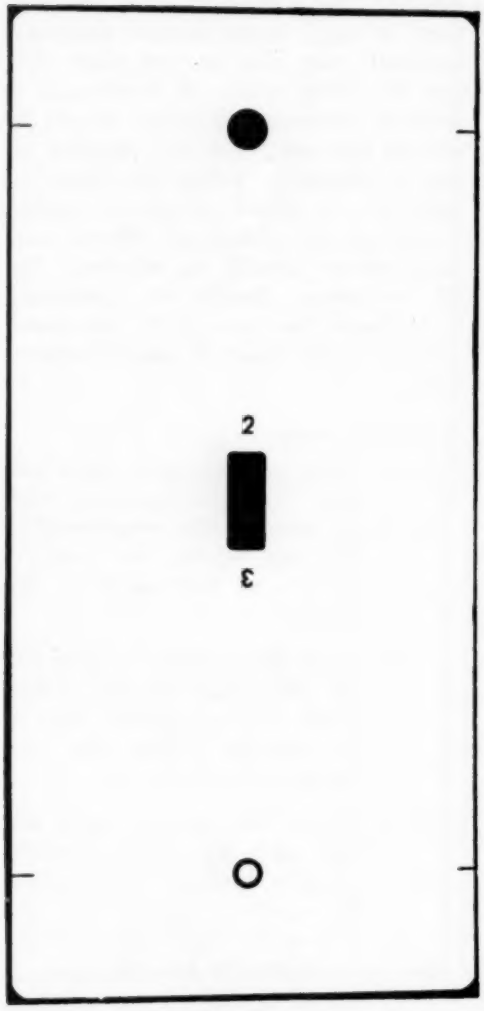

FIGURE 6,a.

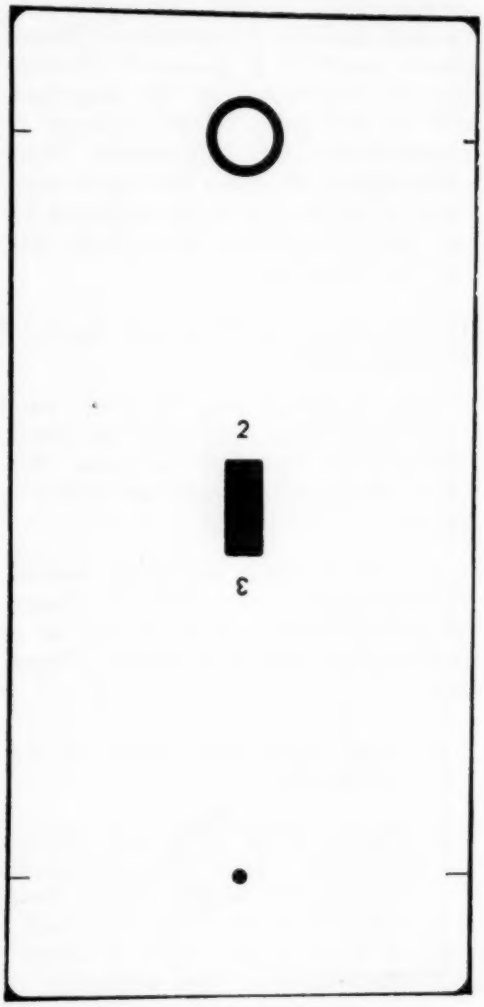

FIGURE 7.

FIGURE 7,a.

is maintained on the ball. Watch his eye in the mirror. If proper fixation on the ball is maintained, the eye will be steady.

e. When suppression has broken so that he sees the ball in the circle as the circle moves across it, ask him to count twenty-five times across and then try to catch the ball in the circle.

f. Note the angle where he caught the ball. Do not be alarmed if he caught the ball at his subjective angle. At this point, repeat the same procedure with the number 2 ball and circle, (figs. 6 and 6,a), then the number 3 ball

and circle (figs. 7 and 7,a). Usually, when superimposition of the number 3 ball and circle is obtained, it is at the objective angle and normal retinal correspondence is present.

g. When the patient has normal retinal correspondence when working with the number 3 ball and circle, use the number 2 rabbits to see whether he has normal retinal correspondence on second grade fusion. Again, if he at first demonstrates abnormal retinal correspondence on fusion, do not be concerned. Try the foveal clowns. If abnormal retinal correspondence is still present, go back to the crossing-over technique with the number 3 ball and circle for two or three days, then try second grade fusion again. When normal retinal correspondence is difficult to maintain at the objective angle, place the foveal clown (the one seen with the preferred eye) about ten to fifteen diopters inside the patient's objective angle so that it will fall inside his angle of squint. A simple tongue depressor can be placed flat at the objective angle while the patient moves the clown from ten to fifteen diopters inside the angle of squint back to the objective angle. (The tongue depressor serves as a stop.) When the clowns appear to the patient to be moving closer together, continue the movement until the clowns bump together several times, then let him attempt to fuse them. They should fuse at the objective angle. Next try the number 2 rabbits, then the number 2 dogs.

h. When normal fusion has been obtained, as much vergence as possible should be developed before surgical intervention. Convergence amplitude should be emphasized first in an esotropic patient who demonstrated abnormal retinal correspondence; divergence amplitude should be emphasized in an exotropic patient who demonstrated abnormal retinal correspondence. In this way one may avoid that area in which the subjective angle originally fell until after the operation.

i. Thirty minutes daily, divided into three or four periods, is essential to a good result in treatment of abnormal retinal correspondence.

III. *Developing Vergence Amplitude*

Either eye fixates on the dog in the mirror while the patient slides the other dog on the opposite scale to the place where he sees one dog with both the bow and the ball. Note the angle at which he fused. To increase the convergence amplitude, move the dog toward the convergent side to the place where diplopia ensues, then back to the place where fusion is regained. The patient should make an effort to hold the dogs together as this technique is repeated. Divergence amplitude is developed in the same way except that the dog is moved toward the divergent side. Vergence amplitudes may also be measured on the smaller fusion targets. Usually, a divergence of five to ten diopters and a convergence of twenty-five to thirty diopters are considered sufficient.

Watch the eye in the mirror. Usually, when fusion is lost the patient will alternate from one picture to the other. The parent must be taught to observe this.

IV. *Antisuppression Treatment*

One finds suppression in manifest squints, phorias and amblyopias. The following technique is used for all types:

A. Technique

1. While the suppressing eye maintains constant fixation on the number 1 ball in the mirror, the preferred or nonsuppressing eye fixates the number 1 circle on the opposite scale. The patient is instructed to move the circle from right to left, keeping as close to the ball as possible, until he sees the ball in the circle as it moves across. After many crossings he should be able to see the ball in the circle and try to hold it there for thirty seconds. When he can maintain the number 1 ball in the number 1 circle, repeat the procedure with the number 2 and 3 balls and circles.

2. Tracing. Place a picture on the side where it may be seen in the mirror. Place a blank sheet of paper on the opposite side and have the patient trace what he sees in the mirror. Tracing may be used in the same way that the cheiroscope is used.

The plastic target carriers supplied with the instrument may be affixed to the chart board, as required, with Scotch tape. The trainer can center them by aligning the guide marks with the horizontal zeros on the chart. When correctly aligned, the center zero will appear in the aperture in the middle of the carrier. In many cases it will be possible to take the divergence or convergence reading by noting the scale mark appearing in the aperture in the middle of the carrier.

All the targets except the clown have been marked according to grade. The instructions refer to them by number as well as by subject matter.

Physiologic Diplopia Reader.

Physiologic Diplopia Reader

The Physiologic Diplopia Reader is designed only for patients who have obtained straight eyes either by glasses or by surgical means. It is also designed to improve the area of comfort for reading in a patient with a phoria, in which the middle third is either too far on the divergent or too far on the convergent side.

The following instructions relate to use of the Reader in cases of accommodative esotropia and phorias at all ages. This includes presbyopic individuals. The instructions are presented in the simplest possible terms.

The main purpose of this instrument is to increase the amplitudes of relative vergences. Relative vergence is that amount of vergence which can be applied without changing accommodation. The end point is either blurred vision or diplopia. Absolute vergence is that amount of vergence which can be applied irrespective of accommodation. The end point is diplopia.

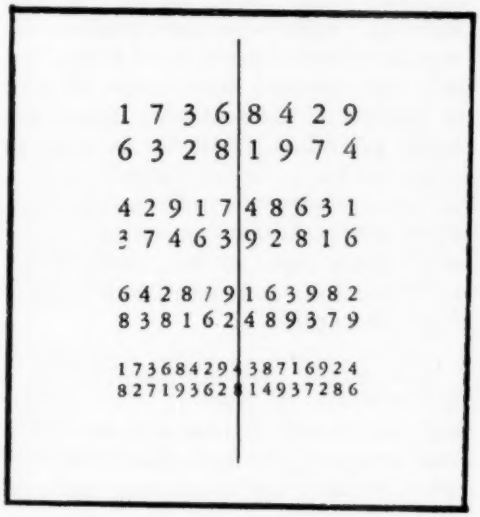

FIGURE 8.

If a phoria is present and one eye is covered, the eye behind the cover deviates. In using the Physiologic Diplopia Reader, tell the child to close his left eye and push the septum forward until the right eye sees number 6 on the top row as the last number to the left. When using the Reader with both eyes open, the septum serves as a cover in front of the right fovea for fixating the first three numbers on the left side, and as a cover in front of the left fovea for fixating the last three numbers on the right side. Bifoveal fixation is present only on 6 and 8, the two center numbers (fig. 8).

If the patient is to maintain straight eyes as he looks from the left side to the right side, a vergence movement is necessary to hold the eye behind the septum straight. If the vision is blurred, only absolute vergence has been applied, but if the vision is clear, relative vergence has been applied. Physiologic diplopia is present on the septum. Because of the accommodation-convergence association reflex, one diopter of accommodation is reflexly associated with approximately one meter angle of convergence. A person who is esophoric and not wearing full hyperopic correction must exert accommodation, which at the same time brings out excessive convergence. To overcome the excessive convergence, relative divergence must be applied. Consequently, as one reads on the Physiologic Diplopia Reader with gradually increased accommodation, he must gradually increase his amplitude of relative fusional divergence to maintain clear vision with straight eyes.

ACCOMMODATIVE ESOTROPIA

A. *Requisite to Developing Relative Vergence*

1. Eliminate amblyopia
2. Break suppression
   a. Diplopia accommodating without correction with crossed eyes
   b. Conscious alternation while maintaining diplopia
   c. Control — the ability to straighten the eyes by blurring the vision and to cross the eyes by clearing the vision
   d. Elimination of foveal suppression by a red filter worn constantly over the lens of the nonsuppressing eye. The patient may do homework

with a red pencil, string pastel colors of seed pearls, trace with a red pencil, sew with pastel colors of thread.

3. Prescribe plus correction sufficient to permit clear single binocular vision

4. Demonstrate appreciation of simple physiologic diplopia and framing with a pencil.

B. *Developing Relative Vergence*

1. Hold the instrument so that the holes are under the nose. The septum is pulled all the way back toward the nose. If the eyes are straight, when the red line is fixated it is seen singly and the septum appears double (physiologic diplopia). It is not uncommon to have to add more plus at near to give single binocular vision. The print should be clear. If the eyes are crossed, when the patient fixates the red line it will be seen double and the septum blocks out part of the line. If the patient has difficulty recognizing physiologic diplopia on the septum, pull it all the way back and cover his left eye while he looks at the number 1 on the top row with his right eye. Then push it forward until he no longer sees the number 1 with the right eye. The number 7 must still be seen. (If the patient has a narrow pupillary distance, when the left eye is covered the number 1 will already be blocked out for the right eye.) On opening both eyes, he will see 736842 framed between the two septums. When the patient has straight eyes with clear vision, he should begin to read from the red line back and forth as follows: 68 863 3684 48637 736842 2486371 17368-429.

Do not move the septum before repeating the same procedure on the smaller sized lines of print until he has clear single binocular vision on the bottom row. At this point he is instructed to close his left eye and fixate the 7 on the top row with his right eye. On opening both eyes he will see 3684 between the septums. He should read from the center, adding one number on each trip back and forth as before. When he has clear single binocular vision on the bottom row, he then closes his left eye and fixates the 3 on the top row with his right eye and pushes the septum forward until the 3 is blocked out. On opening both eyes, 68 will be framed by the septums. Repeat the same procedure until he is able to clear his vision with straight eyes on the bottom row. In order to maintain clear single binocular vision as he reads from right to left, relative accommodation and relative vergence must be applied.

If a slight fusional disparity or a hyperphoria is present, the patient may be unable to obtain clear vision and straight eyes with the 3 blocked out. In this case one may have to settle for blocking out the 7, or even perhaps the 1.

2. Glasses reduction.

   a. After the patient has obtained clear single binocular vision on the bottom row with whatever plus correction is necessary, hook -0.50 fitovers over his lenses and repeat the whole procedure above.

   b. When the patient can appreciate clear single binocular vision on the bottom row with glasses and add -0.50, he should wear the -0.50 fitovers constantly for daily use while he practices with -1.00 fitovers on the instrument. When he has clear single bin-

ocular vision on the bottom row with glasses and add -1.00, he wears -1.00 fitovers constantly for daily use while he practices on the instrument with -1.50, and so on until his glasses are neutralized. At this point he goes without glasses but practices the same exercise with -0.50, then -1.00, then -1.50 to develop a reserve of positive relative accommodation and relative divergence. The fitovers may be hooked on a pair of empty sunglass frames. A total of twenty minutes a day divided into three periods is essential to a good result. Each fitover must be used for practice three to four days before going on to stronger minus lenses.

PHORIAS WITH A LIMITED AREA OF COMFORT FOR READING

A. *Measurement of Area of Comfort*

1. While the patient reads small print at normal reading distance, with a rotary prism increase base in to the point where he appreciates either diplopia or blurred vision; then increase base out until he appreciates either diplopia or blurred vision. Add the base in and base out readings, divide by three, and note where the middle third is. For comfortable reading one should be able to converge with clear single binocular vision twice as far as he can diverge.

B. *Treatment*

1. Be sure the patient appreciates physiologic diplopia with a pencil and that he can frame objects of different sizes.

2. See figure 8 on the proper way to hold the instrument. While the patient fixates the red line, move the septum forward and backward until the patient recognizes physiologic diplopia on it. The red line should be seen singly. Push the septum forward until only the 6 and 8 are framed (physiologic diplopia), then ask the patient to read the numbers back and forth, beginning with 68, 863, 3684 and so on, adding only one number on each trip back and forth until the whole line is read. He should continue reading back and forth on down through the bottom row. He should practice reading the numbers each day for a total of twenty to thirty minutes, divided into three to four periods. If after ten days to two weeks the area of comfort has not improved sufficiently, base in or base out prisms may be necessary to bring the amplitudes within normal limits.

Assembly of the unit is completed by fitting the handle to the main piece, as illustrated. The chart board is slipped over the distal end of the main piece, as illustrated.

The instruments may be purchased locally or may be ordered directly from The House of Vision, Inc., 137 N. Wabash Avenue, Chicago 2, Illinois.

CONVERGENCE INSUFFICIENCY AND FOVEAL FUSION

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MANY orthoptists have emphasized the need for stable first-grade foveal fusion as a basis for good general fusion. Julia Lancaster[1] has said over and over again, "The first step of the 'ladder to binocularity' is fixation. Without good fixation, the patient can go no further."

Fixation is the main prerequisite for first-grade foveal fusion or superimposition—what Aleatha Tibbs[2] has termed "bifoveal fixation." This she has stressed as being far more important than often realized. I am finding it as important in the treatment of phorias with convergence insufficiency as in the treatment of strabismus.

To my office have come sixty-six patients in the last two years with malfunction of eye muscles termed "convergence insufficiency," in various stages of discomfort and binocular malfunction at near. Among them were many who had tried various forms of home therapy in the past and who demonstrated fairly large prism amplitudes and excellent near point of convergence, but symptoms persisted. In these patients, peripheral fusion as measured on the troposcope was usually very good; but in delving deeper to find an explanation for the continued distress, it was found that amplitudes of fusion were almost nonexistent on five-millimeter second-grade foveal targets having one-millimeter check marks.

In working with these patients, I set out first to remedy the faults found, working with smaller and smaller first-grade targets, eliminating supression along the way, until at last first-grade foveal targets could be held superimposed stably with almost no foveal supression. The patient was asked to work at home one-half hour daily with a red pencil, covering his dominant eye with a red filter, until the remaining suppression seemed alternate in nature. Then the red filter was alternated daily.

To get at any hidden suppression on the troposcope, after stable bifoveal fixation was achieved, second-grade targets of decreasing size were used in excursions or "chasing," along with stimulation on the instrument, with no amplitudes attempted, working eventually down to second-grade foveal slides. Finally, second-grade targets having both peripheral or macular and foveal checkmarks were used in the same way to pick up any last traces of suppression. For this, the American Optical Company slides showing the kangaroos are valuable. At this stage, physiological diplopia at both distance and near was being practiced at home by the patient for perhaps ten to fifteen minutes daily, in addition to continued red tracings.

Up to this time, no fusional amplitudes of any kind were attempted, either on or off the troposcope. However, after stabilizing fixation and eliminating suppression, the patient's amplitudes were found to be greatly increased on foveal targets. In using this method patients with convergence

insufficiency, including those with a remote near point of convergence and poor fusional amplitudes, developed comfortable and spontaneous amplitude to approximately twenty prism diopters base out, whereas five prism diopters base out had previously required extreme effort.

Just before the breaking point on convergence, blurring of the images was noted by the patient in almost every case. To get past this plateau, it was necessary to teach the patient to clear the fused image by such means as tracing around the edges of the image and oscillation. Often the fusional amplitudes, foveal as well as peripheral would suddenly increase to thirty prism diopters base out. At this stage, the patient was working at home on a convergence-divergence card.

The surprising thing was that there was no strain or forcing of vergences. When the way was cleared by stable first-grade foveal fusion and elimination of suppression, convergence often came naturally. This would make one wonder whether lack of convergence were a *result* of faulty fusion, rather than a *cause*.

Patients seemed to note relief from symptoms as soon as bifoveal fixation was established, and before any amplitude was attempted. Average length of treatment was approximately eight half-hour weekly sessions, and seldom did treatment extend beyond twelve sessions.

Patients with mild convergence insufficiencies were often sent home to do red tracings and practice physiological diplopia, and a month later were given convergence-divergence card exercises, with little or no office therapy. Patients given regular therapy generally had fairly severe cases. They included several who were considering changing occupations or discontinuing college studies because of severe symptoms. Also given therapy were nine children from eight to thirteen years of age, who were having great difficulty with school work.

Bifoveal fixation is, of course, important in all orthoptic patients, but it may be forgotten at times in the case of the convergence insufficiencies.

All in all, we seem to come back to Miss Lancaster's "ladder to binocularity": fixation (bifoveal); versions; vergences, which begin to come automatically when bifoveal fixation is solidified and suppression eliminated; and accommodation and accommodation-convergence control, which must be regulated at the blur point.

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IDA MANN TECHNIQUE IN CONVERGENCE DEFICIENCY

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It was a little over a year ago that several of us had the privilege of spending one memorable evening with dynamic Dr. Ida Mann. Vitally interested in everything, from chasing kangaroos over the plains in Australia to exploring the hidden depths of a pair of inscrutable, black orbs belonging to a seven-foot aboriginal chief, this charming ophthalmologist from "down under" bloomed when the conversation inevitably swung around to that subject never out of mind for long—orthoptics. It was her enthusiasm over the consistently favorable results obtained in the majority of her cases with convergence deficiency that sent us home in high spirits, raring to try out this magic formula.

Perhaps it is pertinent at this time to note that there may or may not be an inherent difference between the term *convergence deficiency* as used by Ida Mann and our own phrase *convergence insufficiency*. Then, again, this may be one more case in point of establishing universal terminology, since the types of patients considered in Ida Mann's classification certainly bear a strong resemblance to those found in our category.

In any event, we are all familiar with the type of patient who complains of suffering constantly from "eyestrain," of being unable to engage in any close work for any length of time, and of gaining little or no relief from glasses. Such patients frequently arrive with a purse, or a pocket, or even a paper bag full of spectacles in sundry and fascinating styles and colors, which he or she promptly exhibits, like a magician pulling rabbits out of a top hat. The majority of them show a very low grade hyperopic astigmatism and nothing else other than deviation outwards on the Maddox rod and failure to perform convergence as a voluntary action. Some, however, do have a marked anisometropia or heterophoria for distance. Myopia of high degree is rare, though low myopia may occur. Some patients are entirely emmetropic. A large number of these patients impress us from the beginning as being of the neurotic and neurasthenic types, but by no means all. In other words, usually few objective signs can be found to account for a host of symptoms.

In an attempt to bring some order and understanding into this complex and puzzling group, Dr. Mann wrote in 1940:

1. There appears to be no correlation with age, refractive error or muscle balance for distance.
2. There does appear to be a correlation between a deviation of 6 degrees or more on the Maddox Wing Test and absence of the power of voluntary convergence.
3. There is an unknown factor, probably psychological, which appears to be the actual cause of symptoms in some cases since:
   a. Objective signs can exist without any symptoms.
   b. The symptoms do not always disappear when the signs have been removed by treatment.

c. The symptoms may disappear while the signs remain.

d. Return of symptoms may occur without the signs.

e. The symptoms may occur without the signs.

To Dr. Mann, orthoptic exercises designed to produce voluntary convergence and, hence, fusion of stereoscopic cards without a stereoscope appeared to offer good hope for relief of symptoms in most cases. The exercises then in use required the recognition of physiological diplopia as the first stage.

Acquisition of good voluntary convergence did not always remove the patient's symptoms, however. In a paper before the Australian Association of Orthoptic Technicians in 1958, Dr. Mann[2] observed that in many cases it was the ability or inability to recognize physiological diplopia which appeared to correlate more significantly with the presence of symptoms. This long-held premise was supported by a study of 82 persons, 35 of whom were able to perform close work with ease, and 47 of whom complained of discomfort, headache, eyestrain, pain and other symptoms on attempting to read, sew or do close work for more than a short time. The two groups were similar in many respects. Each group was composed of individuals ranging in age from 7 to 70 years. The deviation for near ranged from 4 degrees or less of exophoria to 14 degrees. There were two cases of esophoria of approximately 3 degrees. There were no cases of strabismus or amblyopia in one eye. All had approximately equal visual acuity with correction. None suppressed when dissociated, being able to read the Maddox Wing, but a large number found the appreciation of physiological diplopia extremely difficult. In all patients, it could be elicited, but frequently only after stimulation, major amblyoscope exercises, and explanation. The group without symptoms was able to recognize physiological diplopia instantly, but the group with symptoms had to be trained to see it.

This observation that monocular suppression of physiological diplopia can produce symptoms of asthenopia by interfering with simultaneous macular perception is in accordance with the findings of most orthoptic technicians. Antisuppression exercises are usually in order, and the program will vary with the technician. Dr. Mann personally prefers methods off the major amblyoscope. She feels that a test using perception of physiological diplopia is quicker and more delicate than is the simultaneous appreciation of two different objects as presented by the synoptophore or troposcope.

In teaching awareness of physiological diplopia, Dr. Mann recommends that the patient use his finger as the near object. This appears to be a cogent suggestion, since at least one excuse for not being able to do his exercises is removed. Some object can always be found for distant fixation. Such an object can be a doorknob, perfume bottle, small light, sticker on a door,—indeed, any small target which is easily seen and not surrounded by other objects likely to create confusion.

Exercise 1

While sitting or standing about ten feet from the object, the patient is instructed to hold his finger vertically, about eight inches in front of him in line with the bridge of his nose and the fixation target. He is directed to concentrate his gaze on the distant

object and to try to be aware of two shadowy fingers. When necessary, the finger may be moved slightly to right or left until the distant object is seen midway between the two "ghost" fingers. Next, he is asked to shift his gaze to his finger, which should then be seen singly, with the distant object becoming double—one image appearing on either side of the finger. The above exercise is repeated until alternate fixation of the distant and the near object with appreciation of physiological diplopia can be performed with ease.

Exercise 2

The patient is instructed to concentrate his gaze on his finger and to move the finger slowly from arm's length towards the bridge of his nose, being aware of physiological diplopia of the distant object at all times. The separation between the distant images will be noted to increase as his finger approaches his nose. He is advised to repeat this exercise, moving the finger backward and forward, until he can maintain single binocular vision of the finger as it is moved from arm's length to within two inches or less from the nose. He is encouraged to get the feeling of the muscular action involved.

Exercise 3

The patient holds his finger vertically, about eight inches in front of his nose. Looking at the tip of his finger, he is to note the amount of apparent separation between the double images of the distant object. Without shifting his eyes, he is asked to drop his finger. If the relationship between the distant images remains unchanged, he knows he has not moved his eyes. He is encouraged to maintain this position of his eyes for as long as possible. Although difficult at first, this exercise becomes easier with practice.

Exercise 4

This exercise is similar to Exercise 3 but without the use of the finger. The patient is asked to "double" the target by looking at an imaginary point about one foot in front of his eyes.

Exercise 5

The patient is taught to fuse stereoscopic pictures by converging without a stereoscope. Dr. Mann recommends the Oxford Series. However, since this little package has become a collector's item, the Wells Set can be used to equally good advantage. Cards with true stereoscopic diagrams are used first, such as the E series. Cards with second-grade fusion targets are used next, such as the C series. Later, cards with dissimilar targets are used, for example, the A series. Finally, cards with print are used, which ensures adequate accommodation.

The selected card is held in the reading position with one hand. The finger of the opposite hand is held vertically between the eyes and the card, with the eyes fixating the finger. The finger is moved closer to or farther from the card until the position is found whereby the two pictures on the card are fused. The finger is then dropped, but the patient endeavors to keep the picture fused and clearly seen. If this can be done, he is told to let the picture "break" by looking at the card. He then tries to "re-fuse" the picture by converging voluntarily as in Exercise 4.

It is recommended that these exercises be done for a *short* period several times a day. Considerable improvement in ease of reading should be noticed as soon as Exercise 3 has been mastered. When the patient can do all the exercises, he is advised to repeat them once a week and then

once a month for approximately a year.

SUMMARY

Ida Mann's approach to treatment of individuals with convergence deficiency is presented. Attention is drawn to her observation that absence of the awareness of physiological diplopia appears to correlate significantly with the presence of asthenopic symptoms. In some of these cases, she also feels that an unknown factor, probably psychological, may be the actual cause of symptoms and that it is possible for this psychological factor to express itself as failure to appreciate physiological diplopia. Her technique for stimulating voluntary convergence is described. The recognition of physiological diplopia as a check against monocular suppression is stressed in these exercises.

In presenting this paper, it is recognized that Dr. Mann's method of management of persons with convergence deficiency is familiar to many technicians and ophthalmologists in the United States as well as abroad. It is hoped, however, that recapitulation of her technique will prove of value to each of us.

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REFRACTION IN RELATION TO STRABISMUS

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The ophthalmologist and the orthoptist are well aware that the management of a strabismus problem requires a thorough investigation of the patient's refractive error. They know that the findings of a refraction must be reliable for the orthoptic evaluation and that the recommendations depend on the accuracy of the data received from the referring physician. The physician must, therefore, accept his responsibility and determine the refractive needs of his patient by every means possible. Just as carefully he must follow changes in the patient's visual acuity and the effectiveness of the therapy. These are the doctrines of good ophthalmic practice and they would seem to be self evident. Everyone, however, realizes the difficulties to be encountered in carrying out these principles. Problems related to strabismus must be met early in the life of the child, and cooperation of these young patients leaves much to be desired. For this reason, the importance of re-examinations and re-evaluations is unquestioned.

Although the refraction is an important part of any eye examination, it becomes more important in the presence of disturbances of ocular motility. It must be performed before one can conclusively establish a diagnosis. In determining the refraction, one constantly keeps in mind improvement of visual acuity and the relation of any differences in the visual acuity of the two eyes to the strabismus. I consider the estimation of the vision a part of the refraction. One can consider that refraction begins with the problems of the uncorrected vision and ends only with the final corrected vision.

Orthoptic technician and physician both seek a good visual result in each case of strabismus. They stress the early removal of obstacles to the normal use of an eye. The refraction reveals the optical obstacles which may interfere with the development of a good fixation reflex, of good vision, or of the normal fusion reflex. It aims to determine the type of refractive error present and the presence or absence of anisometropia.

The onset of strabismus has been found to occur in children before the age of 4 in about 75 per cent of cases. Because many of these patients are too young to cooperate, an accurate determination of the visual acuity in such cases is not always possible. Yet each examiner notes on his records the child's responses to accepted stimuli. It is only with extreme patience and repeated attempts to evaluate the visual acuity that any useful information is obtained. This initial phase of the refraction often tests one's ingenuity and will frequently end in frustration. The answer is to try again.

For children who are very young, cycloplegic retinoscopy offers dependable objective information. Full cooperation of the youngster is not re-

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quired. Adequate, if not exact, information can be obtained to enable classifying the child as either hyperopic or myopic, astigmatic, anisometropic, and so on. The dilated pupil affords an excellent opportunity to study the inner eye. This part of the examination must never be omitted. Not infrequently, impaired vision is readily explained on the basis of disease of the retina, or abnormalities in the lens itself. The incidence of strabismus with ocular disease is high early in life. In the presence of opacities of the media or retinal disease which interferes with development of normal visual acuity, the use of occlusion as a therapeutic measure cannot be recommended. If such disease is present, it should be ascertained early in the examination.

At the time of full cycloplegic effect, the refractionist is in a position to determine the total error of each eye. If the cycloplegic effect of the drug is insufficient, the full hyperopic correction remains unknown. Determination of the size of the cylinder is unreliable. Every attempt, therefore, to obtain the fullest cycloplegic effect must be made. In young children, atropine is the accepted drug. Its action is complete and prolonged if it is correctly used. If the full atropine effect is obtained, one can arrive at the static refraction. Atropine, however, is not required in older children and adults; here homatropine and cyclopentolate hydrochloride (Cyclogyl) have their place. Nevertheless, the eyes of some adults, particularly Negroes, may have to be atropinized.

Many large institutions have set up schedules for the use of the cycloplegic drugs and have come to use atropine in solution, recommending its prescription in extremely weak dilutions according to the age of the child. Few toxic reactions have been reported, but they do occur. Before blaming the drug itself, one should check carefully the strength of the solution obtained by the patient. A stronger percentage may have been received than was prescribed by the physician. Then, too, there are people who are sensitive to the drug. I have found one objection to the use of a solution instead of the atropine ointment. This is the frequent occurrence of inadequate atropinization. The active residual accommodation interferes greatly with accurate retinoscopy. It is then necessary to use additional medication or to repeat the examination at a later date. If one must proceed, one does so with certain misgivings and a feeling of insecurity. Should it be necessary to depend on such an examination, an attempt should be made to have the patient relax the accommodation by fixing on a distant object. The office assistant can attract the child's attention with a toy or a light.

For the sake of convenience to the very young patient and to hasten the solution to his strabismus problem, a physician will frequently resort to the use of Cyclogyl. Because this drug has a short action, the patient must be examined at the peak of its effect. This is not always possible in a busy office. The effect of the drug may have begun to wear off by the time the youngster is examined. If the child is unruly, one may examine him before the full effect of the drug has been reached. In any case, the refraction again becomes more of an estimation than a dependable record.

Parents will cooperate to a greater extent if they receive prompt answers to the questions which caused them to bring the squinting child to you. Use of Cyclogyl should be limited to the older group of children in whom

one does not suspect significant astigmatic errors and the accommodative element does not appear to be prominent. It is often necessary to repeat the refraction in an older child or an adolescent who is undergoing orthoptic treatment. If one uses atropine, the inconvenience to the patient is considerable; it interferes with school work, music lessons and numerous other social activities. Here again Cyclogyl has its place.

In discussing re-examinations for visual determinations and re-evaluation of the refractive error, the question may arise as to how often refractions should be performed. Of course this is variable, but the alert orthoptic technician may feel the need to request such studies of the referring doctor. If occlusion fails to obtain a satisfactory result after a reasonable length of time, there is an indication to recheck the cylinder size and axis. In the case of hyperopia, there may be overcorrection, or in myopia an undercorrection. Although the eye in question may be the deviating eye, one must not assume that it is amblyopic. The orthoptist or physician may try the pinhole disc to see whether it will cause improvement of the vision. This can be used over the patient's own glasses. If his present refractive correction is not adequate, he will be able to see better with this device. I am often surprised at the tolerance exhibited by children. I have found them wearing glasses which contain no cylinder when their prime difficulty is astigmatism. I have found a myopic astigmatic correction being worn when actually the child required a hyperopic astigmatic lens.

The discovery of such inconsistencies, as noted above, may cause one to question the ability of the previous examiner. However, we do not know the circumstances under which such glasses were prescribed. In all fairness to the other refractionist, we owe ourselves and the patient the benefit derived from a re-evaluation. Despite the inconvenience to the family and the child, new measurements should be made.

There are few parents who fully understand the program necessary for the management of a squinting child. Although the physician and technician repeatedly explain the procedure and the reason for each step, the questions asked reveal the confusion in their minds. They may be very diligent with the training exercises and try to be faithful in keeping the many appointments. They may appear to accept the physician's explanation in its entirety. But, as time passes, the eye may still deviate. Family pressures and the inquiries of neighbors cause them to question the course of treatment. The physician may be asked disturbing questions, such as, "How long must the child continue to wear glasses?" "Isn't he young to be wearing bifocals?" "Why does his eye still turn if he takes off his glasses?" "Will he outgrow the turn?" "Is surgery absolutely necessary?" The physician must remain tolerant and certainly must avoid a dictatorial attitude. In time, the parents may seek another opinion. This is human nature, although it may injure the physician's ego. But then, just as his patient has gone elsewhere, he, too, will receive patients seen by his colleagues. The parents will bring their child and seek a decision. They have selected him to act as King Solomon. He is faced with a history which is often told in a very guarded fashion so as not to embarrass the other doctor; with a youngster who most likely was very fond of the former physi-

cian; and with a pair of glasses which are reportedly not satisfactory. I urge anyone in such a position to do as the wise king would have done—listen attentively. From there on, the examination must start from scratch.

As indicated above, parents want to be kept informed. If an improvement is found in the visual acuity as the result of the refraction, tell them so. They have to buy the new lens. If the new glasses serve to help the child maintain binocularity, demonstrate this. Any discrepancy in vision resulting from anisometropia should be pointed out. The need for bifocals by their child requires an explanation of the rationale behind such a recommendation. Let them know why in one instance glasses correct a strabismus and in another surgical correction is necessary. I believe Scobee[6] had the right idea when he wrote the small book, "A Child's Eyes." He intended it for the parents.

I have referred mostly to the parent-physician relationship, but the child-parent relationship is even more important. Regardless of the indication for glasses, a child may not cooperate. His refusal to wear his glasses will arouse an anxiety in the mother. The child observes this and finds he has a weapon. The glasses become a means for him to get what he wishes. The parents of children who have a visual defect or strabismus often have a similar defect themselves. These parents often have a sense of guilt, and a child may sense this. He will be pointed out as a child with crossed eyes and glasses who "takes after his father." In the heat of discussion the family may lay emphasis on the fact that there were no such eye problems on his mother's side. To the child, the glasses and his strabismus have become a symbol of something bad. The boy hears the parents say how handsome he is but how unfortunate it is that he must wear glasses. This child may deliberately destroy or lose his glasses. A kind and friendly examiner who plays with and amuses the child as he works can in time circumvent this obstacle. With the aid of well directed flattery, especially in the case of little girls, the task becomes easier. Nevertheless, valuable time has been lost and surgical intervention may have become necessary much earlier than was planned.

The physician's responsibility extends beyond establishing a good rapport with patient and parent, determining the true refractive error, and writing a prescription. The glasses themselves must be checked. This is not always practical, but it should be done at the first opportunity when the child makes a return visit. The prescription must be checked on the lensometer and special attention given to the centering of the lens. Too much leeway should not be allowed between the axis of the cylinder prescribed and that found in the glasses. Although round frames are no longer used, it used to be common to find the axis of the cylinder rotated out of line. A physician must recognize his own errors. The sphere or cylinder may have been written incorrectly or the wrong sign may have been used.

Children will often wear lenses which are so scratched that the correction is no longer adequate and they actually interfere with vision. The position of the frame on the face often requires adjustment. The bifocal segment may be dropped too low for usefulness, or the child may be looking over the tops of his hyperopic lenses. If the temples are too short, the discomfort produced will cause the child to object to wearing the glasses. The plastic nose pads break off and the

rough surfaces cause irritation. The lenses may fit too closely to the eye and the lashes then strike the glasses. In the case of high refractive errors, either myopia or hyperopia, the cosmetic effect of the strong lenses will disturb the growing child, especially the adolescent. Every attempt must be made to make glasses acceptable. If the weight of the lenses causes annoyance, one can resort to plastic lenses. These recommendations serve to make the management easier and to increase the cooperation of the child.

Assuming that the parent and the child have cooperated, and an operation has been performed, the refraction should be checked soon after operation. This is chiefly to evaluate the need for altering the strength of the sphere. Postponement of the change of glasses may have been advised until the operation had been performed. The new glasses may give the child a psychological lift. There are times when the glasses need be worn only intermittently following a successful surgical procedure. Certainly bifocals may have less value following medial recti recessions. All this will indicate to the patient and family that progress is being made.

We are all concerned with the effect of disturbances of ocular motility on the child learning to read. An excellent report by Goldberg on 100 children with reading difficulties made note of several interesting facts. It was claimed that defective vision and muscle imbalance did not have a significant role in the production of a retarded reader. Low refractive errors assumed importance only in that their effect was exaggerated. Interpretation of the symbols was not affected by muscle imbalance or strabismus but by fatigue due to the effort necessary to overcome such weaknesses. This in turn discouraged reading. Those patients who alternatingly fused and suppressed and those with convergence insufficiency tended to become slow readers. Correcting the refractive error and increasing the ability to converge are the means by which we can assist these struggling youngsters.

As a result of the advancement of surgical techniques in the management of retinal detachment, we are seeing successful cases in greater numbers. Also, the final visual acuity in these cases tends to be much better. Everyone is grateful for the opportunity to be more optimistic when recommending surgical intervention. But disinsertion of several muscles and use of polyethylene tubing in the scleral buckling procedure has resulted in a greater incidence of postoperative muscle imbalance. With a good visual result, the patient may be disturbed by diplopia. If the macular damage prevented recovery of good vision, confusion is less likely. Altering the shape of the globe produces a marked change in the refractive error. Sections of tubing, when used, cause a greater astigmatic error; whereas, the circling tube causes marked hyperopia. Fortunately, the changes in shape and size of the globe are not permanent, and as the months pass, the degree of refractive error lessens. A new and softer material, silicone, does not produce as much global distortion and will be used more as time goes on. The refractionist does not attempt to give the patient binocularity if the anisometropia is too great. With the passage of time, the eye may return to its preoperative refraction needs. Nor is the correction of the strabismus advisable unless cosmetically necessary. Most individuals suppress and adjust well.

SUMMARY

The importance of a thorough refraction in the strabismus patient and of the need for repeated evaluations of the visual acuity and of the prescription has been stressed. Only by constant vigilance will it be possible to obtain a successful outcome and to eliminate a major obstacle to the attainment of useful vision and binocularity. The significance of the glasses in the child-parent-physician triangle cannot be minimized. The accuracy of the prescription and the comfort of the patient are the physician's responsibility. The orthoptist can continue to help by remaining alert and bringing to his attention any abnormalities which are related to the refraction.

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Illumination and Its Relationship to Visual Acuity and Oculomotor Function

PART I

THE PHYSIOLOGY OF VISION, SOME BASIC CONCEPTS

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THIS discussion of the physiology of vision is simply a brief review of the literature to provide a background for the other portions of this symposium and to gain a better understanding of illumination and its relationship to visual acuity and oculomotor function. I have drawn heavily from Adler's *Physiology of Vision*.[2]

How do we see? Light and vision are the basic requirements.[1] There must be enough light to illuminate an object in order to make it visible. The organism must possess an adequate visual apparatus to receive and perceive the object. The visual perception of an object is a complex physiological and psychological process[4] which we will break down into simpler categories, touching on the physiological processes only.

First let us examine the nature of light. It can be defined as "that group of wave lengths in the energy spectrum capable of stimulating the photoreceptors in the retina and producing a conscious sensation called sight."[2] All energy that exists in the universe is a part of the energy spectrum, and all parts of the spectrum are identical in their electromagnetic nature, with the exception that each part has its characteristic wave lengths. The total range of wave lengths in the energy spectrum is beyond human comprehension: the longest wave lengths are radio waves which may be over a mile long; the shortest are the cosmic rays, which are one one-hundred-millionth of a millimeter long. Between these two extremes are the visible wave lengths which constitute light. Their length ranges between 390 and 750 millimicrons, one millimicron being the one-millionth part of a millimeter. When the entire range of visible wave lengths strikes the human eye, a sensation of white light is produced.

In considering the physical measurement of light and its effect on the eye, we must keep in mind three concepts: the source of the light, the illumination, and the brightness.

The power of a light (its luminous intensity) is measured in terms of a standard candle. The light emitted is defined by the term *lumen*, and the unit of measurement of illumination is called a *foot-candle*. If a standard candle is at the center of a sphere with a radius of one foot, each square foot surface of the sphere receives one lumen, and the illumination on that square foot is one foot-candle. Illumination varies with three factors: the

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power of the source of light, the distance from the source, and the angle of incidence. Brightness is expressed in terms of lamberts. One lambert equals one lumen per square centimeter. Brightness is a sensation and is independent of the distance. However, the size of the pupil is of importance in all measurements involving brightness discrimination. The stimulus necessary to evoke a definite sensation is defined in terms of brightness, candles per unit area, and pupillary area. Two important factors are the condition of the ocular media and the amount of pigment that is present in the retina, for these determine the available energy which ultimately reaches the rods and cones.

A brief mention of lighting standards seems in order. In general, what amount of light is needed for healthy eyes to work? No attempt will be made at this point to answer this question specifically, but some generalizations may be helpful. One must consider the visual acuity demanded for the visual job, the speed of vision desired, comfort, freedom from strain.[2] There must be adequate illumination both on the work and in the room so that there will not be a marked contrast. For most reading, 10 to 15 footcandles is considered best. The more nearly the quality of light approaches that of daylight, the better. With print or fine near work, the highest contrast possible is desirable, for example, black print on white paper, black thread on white cloth. Glare should be eliminated, for it is useless light which serves no function, and causes fatigue and strain. Another source of fatigue is unsteadiness of illumination such as that found in some fluorescent light.

Let us consider the photochemistry of vision. In order for visual sensation to arise, energy from the visual spectrum must be absorbed by the retina to produce a photochemical reaction. Substances which can absorb light are called pigments. These pigments present in the human eye are called carotenoids.

Rhodopsin (visual purple) will be considered first. This is a magenta photosensitive pigment found in the rods and its presence is essential for normal vision in dim light. When the eye is exposed to light, the rhodopsin undergoes a chemical change, becoming bleached. The pigment is regenerated in the dark or in dim light. Probably the chemical change is as follows[3]: when rhodopsin is bleached by light, it first turns an orange color which changes rapidly to yellow and finally becomes colorless. The visual purple (rhodopsin) breaks down during bleaching into protein and an orange-yellow carotenoid pigment called retinene. The final colorless product is vitamin A. The vitamin A does not accumulate in the retina but is carried away in the circulation. Regeneration of rhodopsin from vitamin A takes place in the retina during dark adaptation, when the eye is no longer exposed to light. Thus, the first phase in the visual process occurs in the retina, and by a photochemical process, radiant energy is converted to electrical energy (nerve impulses). Thus the photochemical pigment, rhodopsin, plays an essential role in vision in dim illumination, which is scotopic vision.

Although evidence for a photochemical theory for daylight vision, or photopic vision, is not as complete, it is considered highly probable that foveal vision is also dependent upon a photochemical mechanism. A pigment called iodopsin (visual violet), which is considered to be very similar to rhodopsin, is thought to be present

in the cones only, functioning in the same way as rhodopsin, but for photopic, rather than for scotopic vision.

The retina has the ability to automatically adapt itself within a rather short time to changes in light intensity. We call this light and dark adaptation. Light adaptation is the adjustment of the retina to light (photopic vision), and dark adaptation is the adjustment of the retina to dim illumination (scotopic vision). For example, when coming from a dark room into one which is brightly lighted, the eyes are temporarily blinded, but they very quickly adapt themselves and vision returns. Only a minute or two is required for the adjustment. The pupil contracts at first, and this is helpful, but retinal adaptation is the major factor. Eyes which are light adapted become dark adapted when the light source is removed, but this is a much slower process. When the light source is first removed, dimly illuminated objects cannot be seen at all, but gradually become visible although no change in the illumination occurs. Dark adaptation takes nearly an hour to be completed, but approximately 61 per cent of the process is attained in the first five minutes.[2] When dark adaptation is complete, the fovea is a "blind spot," due to the enormous increase of sensitivity of the peripheral retina. Thus, in order to see a distant point of light at night, such as certain dim stars, one must look slightly to one side of the light so that it will fall slightly off the fovea onto a peripheral area of the retina, thus permitting it to be seen.

Let us now examine certain sensory visual responses which we call *primary images* and *afterimages*. The primary image is the actual image of the object seen. This image lasts momentarily after the stimulus is no longer presented to the eye. The primary image is immediately replaced by another primary image, if a different object is immediately seen, in which case no afterimage has an opportunity to appear. However, if the primary image is not followed immediately by another different primary image, an *afterimage* of the original primary image will appear. The afterimage is a succession of fluctuating sensations which may occur after the eye has been stimulated by light, and the nature of this afterimage will depend on the way in which the eye is stimulated.[2] A momentary stimulus of a bright light produces an image of the light which is the same color when the eyes are closed or turned toward a dark background. This is a positive afterimage. A negative afterimage is produced by looking at a light background, and the afterimage will then be of a complementary color. Afterimages are produced only when the eye is exposed to the original stimulus much longer than the time required to produce vision of continuous and successively presented light stimuli.

The afterimages arise from photochemical processes in the retina; they originate in the retina, not in the cortical centers. However, cortical processes may exert inhibitory influences on afterimages.[2] We are not ordinarily conscious of afterimages. This is due in part to the fact that our eyes are continually shifting from one fixation point to another; as a result, the image on the fovea is constantly changing. This is in keeping with an observation regarding the effect of stimulation of the retina by light; that is, when one stimulus is received by the retina there is a small period of time immediately afterward in which the retina is less sensitive to a second stimulus similar in kind to

the first, but more sensitive to a different kind of stimulus. The afterimage takes place during this period.[2]

A phenomenon called *flicker* is important in considering the physiology of vision. It has been observed that intermittent flashes of light presented to the eye are perceived as separate as long as the rate at which they are presented is below a certain value. A slow rate makes the light seem to go on and off. When the rate of presentation of light is increased, the light appears to stay on constantly, but shows rapid alternations of intensity, producing a sensation called *flicker*. The sensation of flicker lasts up to a certain critical rate of flashing of light, but beyond that rate, when a faster rate of flashing is produced, the flicker suddenly ceases, and the light appears to shine steadily with the same intensity. This phenomenon has been used for the estimation of retinal function under many different conditions.

The *critical fusion frequency* is the rate or frequency per second at which an intermittent light loses its flicker and appears to shine steadily.[2] Why does this "fusion" of intermittent light occur? It is due to the phenomenon we have already discussed, that of the primary image lasting for a brief moment after the initial stimulus. The fusion of successive stimuli occurs when the primary image of the next stimulus appears. Thus, if the intermittent stimulus is spaced at just the right intervals, a sensation of constant light will be elicited by the individual. The cortex is in part responsible for the changing of intermittent stimuli into continuous sensation, but most of the change occurs in the retina itself.

The light sense is considered to be the simplest function of the retina. It can be defined as the discrimination between light and dark. The retina has a duality of purpose, the cones of the fovea functioning for bright illumination and the rods in the periphery for dim illumination, thus it is two sense organs in one.

Form sense (visual acuity) is a function of the cone area, and this requires the integrity of the eye as an optical instrument, for it is the function of the dioptric apparatus to form a clear distinct image on the retina.[1]

The color sense is a special development of the light sense and is a function of the cones. In daylight most objects have color. They lose their color when the illumination drops to a certain level of dimness, due to the fact that color depends partly upon a mechanism in the eye which only functions above certain light intensities. The color of an object also depends upon the property of the object of absorbing certain wave lengths of light and reflecting others back to us. The quality of the light which strikes the object before it is reflected to our eyes is important in producing colors, for if the light contains only some of the colors of the spectrum, the object cannot reflect back to us any of the colors lacking in the light which illuminates the object. For example, if the light falling on a leaf contains no green, the leaf cannot then reflect these particular light rays back to us, and therefore the leaf cannot appear green.[2] Although the sensation of color is a psychological attribute of vision, it has a physical and physiological basis.

White light is a mixture of the eight colors of the visual spectrum. Each of these colors has a different wave length, from the longest, red, through orange, yellow, green, blue-

green, blue, indigo and finally the shortest, violet. White light striking a prism is dispersed into its component wave lengths and thus we see all eight colors. The color of an object will depend upon whether or not the particular wave length it transmits or reflects is present in the light which illuminates it.

Color has several attributes, hue being the one just described, that is, the colors of the spectrum. Brilliance is that attribute which measures the variations among the grays from white to black. Intensity is another characteristic which must be present. One red light can be brighter, but have the same hue as another red light. A red pigment may be made darker by mixing with it some black pigment. The reflected light from the surface, which reaches us, will be less intense than before the black pigment was added. The gradual admixture of black to a spectral color produces the shades of that color.

Color possesses another characteristic called saturation. Most spectral colors in nature are not pure, but are mixed with white light to varying degrees; these are called *unsaturated.* Such unsaturated colors may be referred to as tints of a certain hue. When white light is mixed with light consisting of one color only, the tint of that color is changed. Thus, a pure color (hue) such as red may be mixed with white to produce pink. Yellow-green and blue do not change with the addition of any quantity of white light, but just become more unsaturated. As more white light is added to certain spectral colors, they become more unsaturated and finally appear to be white.[2]

The three primary colors of the spectrum are red, blue and green. All other colors are produced by combinations of these wave lengths. Complementary colors are those colors of the spectrum, any two of which produce white when they are mixed. The complementary colors are paired as follows: red and greenish blue, orange and cyan blue, yellow and indigo blue, greenish yellow and violet.

A curve has been plotted for the normal human eye showing the relative brightness of all of the colors in the spectrum under conditions of good daylight.[2] The brightness is quite different for the various colors. The eye in daylight vision sees the green and blue-green at the middle of the spectrum most brightly, and the colors at each end, red and violet, most dimly. A different curve can be plotted for dim illumination, which constitutes a shift in the sensitivity of the eye to color during dark adaptation; this is known as the Purkinje phenomenon. This is of great theoretical importance, for it is one of the fundamental indications for the duplex nature of the retina. As dark adaptation begins to take place with the onset of dim illumination, the cones no longer work and only the rods function. Then the color sense is lost and all colors resemble each other except for different degrees of brightness.

There are several theories of color vision, but the one generally accepted as the most accurate is the Young-Helmholtz theory, which is based on the assumption that there are three fundamental color sensations due to the presence of three different kinds of photoreceptors in the retina. This is assumed to be true because the retina, when stimulated by the three primary colors, produces all of the color sensations of the spectrum. This theory also explains the phenomena of negative afterimages. Color vision as a function of the cones is not entirely

a retinal function but is largely a cortical function as well. Rod vision is considered primarily a retinal function involving little activity on the cortical level.

Color blindess is mentioned here briefly, only because the investigation of this condition helps substantiate the Young-Helmholtz trichromatic theory of color vision. The color-blind individual fails to perceive red when there is an absence of the photochemical substance which transmits the sensation of red, the same being true for the green or blue color blindness.[5]

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Illumination and Its Relationship to Visual Acuity and Oculomotor Function

PART II

ILLUMINATION AND VISUAL ACUITY

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WHEN measuring visual acuity we are actually measuring the form sense, which depends upon illumination for its functioning. The proper amount, quality, and distribution of the illumination are all involved in our ability to see clearly and to discriminate the contour and the details of an object. Needless to say, if illumination is lacking, or if the light is very intense, vision is impossible. But it is not the absolute intensity of the light that determines our ability to see an object; instead, it is the difference between the illumination of the object and that of the surroundings. As one writer has said, "We see by contrast."[8]

In order to see "form," the brain must distinguish between the illumination of the object, such as a letter on the visual acuity chart, and light from the background. This is known as brightness contrast, or the contrast between the test object and the background against which it is viewed.

Visual acuity has been shown to be markedly less for a black object placed against a gray background than the same object placed against a white background. This is true for any given level of illumination. In both cases visual acuity shows decided improvement with increase in the illumination upon the background.[5] Beginning with low illumination on the background, the visual acuity will improve rapidly as the brightness of the background is increased; after the background illumination has reached a level of intensity of one foot-candle* the visual acuity increases more slowly with further increase in the brightness of the background.[7]

On the commonly used visual acuity test-charts, the contrast between the black test letters and the white background is very high, generally greater than 95 per cent. Because the brightness contrast is so high, the reading obtained is of limited value in giving us an estimate of how well the person sees for the performance of everyday visual tasks. The visual acuity testing situation is ideal for visual performance because of the high brightness contrast; the brightness contrasts under ordinary seeing conditions may range from 0 to 100 per cent.[5] Most of us probably have not stopped to consider that when a person is working at visual tasks in-

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*A foot-candle, the unit for measuring levels of illumination, is approximately the illumination produced on a vertical surface placed one foot away from a standard lamp of one candlepower.

volving very low brightness contrast, he has for the time the equivalent of very poor visual acuity under more adequate levels of illumination. When considered in this broader sense, visual acuity is not solely a function of the visual mechanism, but it involves eyesight, the type of visual task, and the seeing conditions under which the task is being performed.[5]

Visual acuity is influenced by the distribution of illumination in the field of vision. Excessive illumination in the peripheral field causes a reduction in visual acuity and fosters the formation of afterimages. Excessive light, such as would be found in reading outside at noon on a clear day, can reduce form vision by causing blinding glare, which reduces the sensitivity of the retina.[2]

We would, at this point, like to review briefly the basis of visual acuity tests before considering how illumination influences visual acuity specifically in a testing situation. The form sense is studied experimentally by measuring visual acuity, or the ability of the individual to discriminate fine detail. Usually the minimum separable, or the resolving power of the eye, is accepted as an index to visual acuity, resolving power meaning "the smallest angle subtended at the nodal point of the eye by two points such that they are appreciated as distinct."[1] According to this definition, visual acuity is expressed as the reciprocal of this minimal angle in minutes. One method used to determine the resolving power of the eye is to find the minimum separation between two objects, such as two lines or bars, that still allows them to be recognized as two separate and distinct objects. The well-known Snellen test chart is essentially a resolution test, or one which measures the resolving power of the eye.

Snellen was the first to construct a test chart that had a rational basis. He found that the average individual can resolve the details of a letter if they subtend an angle of one minute of arc at the eye. Actually the resolving power of the eye is even greater, a figure of twenty seconds of arc being accepted as the anatomic limit of resolution of two points by the most central part of the fovea.[1] But Snellen arbitrarily decided upon block letters of such size that the letter as a whole subtends an angle of five minutes of arc when the chart is placed a specified distance from the eye. The details of the letters, the width of the black lines forming the letters, and the spaces between the black parts are of such size that they subtend an angle of one minute of arc at the required distance. Visual acuity as measured by the Snellen chart is expressed in the Snellen fraction, which is the ratio of the distance of the individual from the chart to the distance at which the minimum legible row of letters should be read by the person with normal vision. The A.M.A. chart is based on the same principle of size and distance as the Snellen chart, but the method of rating for the A.M.A. chart is in terms of visual efficiency.

The details or strokes of the letters on the 20/20 line of the Snellen chart subtend a visual angle of one minute when the chart is twenty feet from the observer. A person with normal vision should be able to read these letters under an illumination of 10 foot-candles when he is twenty feet from the chart.[6] Although the letters may be just legible with illumination of 10 foot-candles, it has been found that among persons with normal vision, visual acuity increases about 40 per cent when the level of illumination of the test object is increased from

10 to 100 foot-candles.[5] Hartridge[3] reports the results of work by Gilbert and Hopkinson on the effect of variations in illumination on visual acuity as measured by the Snellen chart. The level of illumination was varied from 0.1 to 100 foot-candles, and in every case acuity improved with increase in illumination. Usually if the light is increased by ten times, there is an improvement of one line on the Snellen chart. The effect of increasing illumination is somewhat less for persons with good acuity and somewhat more for those with poor acuity.

Luckiesh[5] describes studies made to determine the range of visual performance for persons with average vision when the illumination ranges from 1 to 100 foot-candles. Increasing illumination from 1 to 100 foot-candles produced an increase in relative visual acuity from 57 to 100, an increase in Snellen reading from 20/40 to 20/20, and an increase in visual efficiency on the A.M.A. chart from 85 to 100 per cent. It may be seen from figures such as these that illumination has a significant effect on visual acuity, even for persons with normal vision and for test objects of high brightness contrast, as is characteristic of black letters on a white background. The effect of illumination of the test chart usually is not noticed particularly because the commonly used charts have such large steps and because most eyes have considerable accommodation reserve, but the effect is certainly significant, and in borderline cases the level of illumination may be the determining factor.[5]

Now we may ask, What are the best lighting conditions for testing visual acuity? An answer to our question is suggested by the studies cited, which seem to indicate that illumination of 100 foot-candles gives the highest visual acuity reading. A different type of experiment was carried out by Simonsen and Brozeh, in which the task was to identify small letters presented to the eye at a constant rate of thirty per minute. Here again the most accurate results were obtained with illumination of 100 foot-candles.[3] Some writers have emphasized that good general illumination is the critical factor in lighting for visual acuity testing. Linksz[4] states that Dr. Lancaster's objection to projected Snellen charts was that they have to be used under poor general illumination. Using a conventional test chart in good illumination, the paper usually reflects about 80 per cent and the print 4 per cent of the incident light. The best possible reading of visual acuity will be obtained under these conditions. But, using a projection instrument it is difficult to regulate the lighting so that it will be conducive to good acuity. If the room is well lighted, as would be indicated for best form vision, the contrast will be poor. On the other hand, if the room is more dimly lighted, the contrast will be better, but under these conditions the available cones will not be allowed to function to their capacity and we cannot expect to obtain such high acuity readings.[4] For this reason Linksz has emphasized that visual acuity should be tested in a well-lighted room, against a light background, not in a darkened room or against a dark wall.

Visual acuity testing has been characterized by a lack of standardization of the level of illumination, the lighting used in various offices probably ranging anywhere from 100 foot-candles down to one foot-candle. Comparable values cannot be obtained with such a wide range. In addition, such a difference in lighting may de-

termine whether or not a person passes certain visual requirements. As mentioned earlier, the level of illumination is most critical for persons with reduced acuity.

Thinking of vision in the broader sense of "seeing" or how well we actually see for a particular visual task, as we have tried to do in this discussion, visual acuity is not a fixed and unalterable ability of the eyes; instead, it depends upon the object being viewed and upon the illumination of that object and of the background. Duke-Elder has said, "The eyes of man were evolved to function in daylight."[2] If this is true, then we should attempt to duplicate daylight as nearly as possible when testing visual acuity or adjusting the light at home for reading or other detailed use of the eyes. Since it is necessary that our eyes be able to function most acutely under artificial illumination, we are fortunate that we are easily able to control the illumination factor in any visual situation.

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Illumination and Its Relationship to Visual Acuity and Oculomotor Functions

PART III

LUMINANCE AND VISION

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The act of seeing involves basically two indispensable factors: light and the eye. In man, the brain must be included, since the eye is developmentally a part of it. This being fundamental, we are impressed in studying the work of various authorities and from our own observation that on this basis is built an endlessly complex phenomenon. We shall use the term *luminance* for expressing what most of us have come to call *illumination*. The relationship between the amount of light one should use in visual discrimination, functioning of oculomotor mechanisms, accommodation and convergence will be considered.

In visual tasks in which high levels of accuracy are required, the amount of light used affects the visual function. As the amount of light is increased, there is an increase in accuracy, notably when detail is small. One therefore wonders whether the accuracy will continue to increase with increasing luminance. Whether more light improves visual performance depends greatly on what one is trying to see. If what one is trying to see is large, then lesser amounts of light are sufficient; if what one is trying to see is very small, increased amounts of light are essential.[1] People who have a difficult visual task to perform may take their work out of doors for better illumination.

Research will be required to provide further answers as to the relationship of luminance and vision. This research is of interest to us and can be briefly described. Beginning with the study of very simple, uncomplicated forms, it has been found that circular objects are the simplest and rectangular objects are next in order; to achieve comparable accuracy, much more light was needed in viewing rectangular objects. The next figure studied for comparison was a cross. It was found that more light was required to see the cross than was required to see the circle. Thus it has been found, that when the visual task can be controlled and reduced to its simplest form, the different shapes require different amounts of light. Also, the farther an object is in the periphery, the more light will be needed. In general, the more light, the better the visual acuity where there is a uniform background.

GLARE

Glare is another factor which reduces the ability to see detail. Blackwell[1] states that in introducing a source of glare somewhere near the object of regard, two things happen: (1) it increases the effective luminance level, which is a good thing, and (2) it decreases the target con-

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trast, which is not desirable. A common example is the washed out detail adjacent to oncoming headlights. There is a definite exchange rate for light and glare which can be calculated. Light sources should therefore be adjusted to the visual tasks that have to be performed.

LUMINANCE AND THE OCULOMOTOR FUNCTIONS

A second basis upon which we must evaluate the type and amount of illumination is the function of the oculomotor mechanism. The influence of light levels on the oculomotor system has been of interest to many authors. We note in some cases of amblyopia ex anopsia that increasing the amount of light before the amblyopic eye on the major amblyoscope is often helpful.[2] But in many cases it has not produced the hoped for increase in visual acuity. While many amblyopic individuals see better with the increase of light level before the amblyopic eye, some seem to fuse more readily with reduced luminance.

ACCOMMODATION

Blackwell[1] was concerned with the relationship of light levels to accommodation, evaluating the near point and far point at various luminances. Without going into details of the laboratory procedures, the experiments showed that with a very high light level (about 60 foot-lamberts) the near point was closer and the far point farther than in reduced illumination for young observers; the amplitude of accommodation is therefore reduced in dim light. Blackwell found that the near point reached an asymptote at about 60 foot-lamberts but the far point did not. He found that more light seems to improve the amplitude of accommodation and that a larger amplitude of accommodation improved ocular performance and comfort.

ACCOMMODATIVE VERGENCE

Another phase of the above experimentation involved accommodative vergence. Electrodes were put on two sides of the eye, the potential difference between the two electrodes which occurs when eye muscles are innervated was measured. When the eye accommodates, there is a reflexly associated convergence which tends to align corresponding points of the retina. Blackwell[1] states that this reflex to converge in near accommodation is not attached to the stimulus to accommodation, "what one sees," but is attached to accommodation itself. He also measured how well this accommodation vergence occurs reflexly at different luminance levels. In experiments involving nearly 1000 foot-lamberts, Blackwell and his group[1] found that the accommodative vergence reflex is reduced at low light levels. This author believes that his findings are of importance in industry. These facts are of interest to orthoptic technicians, since we often find in questioning patients that there are visual difficulties relating to working conditions. In order to maintain fusion, total vergence appropriate to the state of accommodation is necessary. The amount which the accommodative vergence provides is only a part, and whatever additional vergence is required must be provided by fusional vergence. It is believed that fusional vergence may lead to asthenopia.

As has been suggested, much research remains to be done before all of these complex relationships may be properly evaluated.

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ROLE OF SUPPRESSION AND RELATIVE ACCOMMODATION IN ORTHOPTIC PROGNOSIS

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OBSERVING the many characteristics of fusion or the lack of them makes evident a certain behavior pattern which can be a valuable guide to orthoptic prognosis. Frequently there is no clear-cut absence or presence of fusion in untreated strabismic children. There is much difference between fusion at its highest sensory level and fusion at its lowest physiological level. The fact that a patient has a massive suppression in one eye, making fusion an impossibility, does not by itself indicate that fusion is absent above the suppression level. This may be academic when treatment is not given in the so-called "difficult cases," but it is highly significant when fusion training is given.

SUPPRESSION PATTERNS

A study of the fusion and suppression patterns in heterophoria is most helpful in evaluating strabismic suppression. Certain findings are noted. Macular suppression, usually mild in nature and readily responsive to treatment, is found in heterotropia that is intermittent. Peripheral suppression is relatively rare. A foveal suppression of varying intensity is found in all heterophorias, the majority monocular, as in strabismus. The comfort of the patient is in direct ratio to the breakdown of the foveal suppression except in those persons with little or no relative accommodation. When the foveal suppression is marked, the patient has the usual complaint of a "sandy" feeling of lid irritation, or "salt stinging the lids." This symptom is especially common with the exophoric complainer. Some blurring is noted, usually for near, and a higher correction of the refractive error is commonly given by the ophthalmologist in charge.

Since peripheral and macular suppression play only a minor role in heterophoria and are usually amenable to conventional treatment, they do not require discussion here.

Foveal Suppression

Foveal suppression is demonstrated in three behavior patterns and elicited with dissimilar foveal pattern slides on the major amblyoscope.

1. Suppression at the angle of superimposition, with foveal perception to either side of the angle. This is usually a facultative type of suppression, present in heterophoria and tropia.

2. No suppression at the angle, but the nonfixated foveal image moves "up and down" at the angle, becoming level at either side of the angle.

The patient describes this as "dancing" suppression and is usually obligatory, present in heterophoria.

3. No suppression, but the nonfixated foveal image moves through the angle to either side; "in and out" suppression. This type may be either facultative or obligatory, the faculta-

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tive type being present in heterophoria or tropia, the obligatory type in tropia.

The best method for study of the foveal suppression patterns is with the major amblyoscope and suitable slide material. Similar and dissimilar foveal patterns are used, in conjunction with macular and peripheral slide patterns circumscribing the foveal patterns. It is revealing to check the suppression with the smaller of the two dissimilar foveal slides in front of one and then the other eye, and then check with similar foveal pattern slides, noting how the suppression characteristics are demonstrated with the different slide presentations.

It is very useful to differentiate between facultative and obligatory foveal suppression for prognostic as well as clinical evaluation. The duration of the suppression does not necessarily give the answer. An obligatory suppression may be verified in 3-year-olds with strabismus of short duration; on the contrary, a facultative foveal suppression may be found when the tropia or phoria is of many years duration.

If the stimulation or relaxation of the accommodation affects the foveal suppression for better or for worse, it is facultative and a prognosis of relatively rapid deterioration of the suppression with training can be made. But if the stimulation or relaxation of the accommodation has little or no effect on the foveal suppression, the training period is lengthened by many months. When the accommodation is controlled with corrective refractive support, the facultative foveal suppression is eliminated, partially or wholly. When the suppression is obligatory, relaxation of the accommodation has no effect on the suppression.

Suppression at the angle of superimposition is the least complicated of the foveal suppression patterns, but this does not imply that it is easy and simple to overcome; only that it does not play the game of duplicity to thwart the efforts of the orthoptist. Since it is usually facultative, it responds more quickly to conventional suppression therapy.

The foveal suppression patterns, distinct as they are from each other, may follow each other in natural sequence during the training procedures. A foveal suppression which starts as an angle suppression may, while under treatment, become a dancing suppression, and then change into an in-out suppression. However, the dancing and in-out forms, as such, may not have an angle suppression as an antecedent form, or as a *sine qua non* condition of their being elicited.

Dancing suppression can be and usually is the most difficult of the foveal suppressions to break down. Persistent and well-directed efforts in suppression therapy are necessary to remove the dancing foveal suppression permanently and the duration of treatment is doubled.

When nystagmoid or dissociated forms of oculomotor anomalies coexist, a foveal suppression is always present, usually the dancing type. Intensive training and rigid accommodative control assure a good prognosis, though the treatment may take several months longer.

The In-Out Suppression pattern requires critical analysis to avoid a misleading prognosis. It is readily amenable to conventional treatment when it is facultative. However, if it is of the obligatory type, more time is required to remove it and can be as

difficult as the dancing type to cure permanently.

There is no method or symptom complex by which the orthoptist can prognosticate the length of treatment from beginning to termination with cure, in the 2-to-4-year-old squinter. This is due chiefly to the inability to obtain correct information from the patient. The prognosis in these and all other cases depends upon the breakdown of the foveal suppression.

One finding will give conclusive information that fusion is absent above the suppression level; that is, absence of a crossing point of images at any angle position on the major amblyoscope. In older children and adults, the complete absence of physiologic diplopia can be a "red signal" of no fusion and a poor prognosis for fusion training, or that the training will be long and arduous.

RELATIVE ACCOMMODATION

This subject cannot be discussed without considering suppression. When studying the development patterns of some of the many strabismic cases seen, the question arises, "Which comes first, suppression or loss of relative accommodation?"

Our eminent teachers and our patients have taught us the classical symptoms of the regression process in the loss of fusion in strabismus: diplopia, loss of retinal rivalry, suppression, amblyopia, which may be accompanied by a breakdown of the sensory integrity of retinal correspondence. Yet, when the process is reversed, starting at the terminal stage of the breakdown, our first efforts are directed toward the restoration of the lost vision and the sensory integrity. This is accomplished chiefly with the stimulation of foveal fixation of the deviating eye. At this stage, accommodative control is usually given by the ophthalmologist in charge. When treating the next symptom, suppression, accommodative control is clearly indicated, along with other safeguards to the foveal fixation of the deviating eye. Therefore, a closer scrutiny of the patient's symptoms will corroborate this need. The list of "classical" symptoms is now enlarged to include *loss of relative accommodation.*

Relative accommodation, operationally defined, is the amount of binocular accommodation that can be stimulated, resulting in maximum depth of sharp vision, while the convergence remains static or fixed. As an example, ability to fuse orthophorically a Snellen test chart 20 feet distant, with —3.00 spherical lenses placed in front of each eye, and clearing the print on the chart to the 20/20 line.

The loss of relative accommodation can be verified in all cases of strabismus and to a lesser extent in all phorias. Whenever suppression is found, a reduced relative accommodation is also present, greater for near than for distance. An easy, gross check of reduced relative accommodation is a comparison of the binocular vision, with glasses and without glasses, in heterophoria and intermittent strabismus. The uncorrected vision is reduced below that of a person with normal relative accommodation and identical refractive conditions. In the case of tropia, loss of relative accommodation is self-evident with loss of binocular single vision. In intermittent tropia, when binocular single vision is present without glasses, the binocular vision is markedly reduced in addition to the reduction caused by the refractive error.

When the accommodation is controlled with refractive correctional

support, the suppression is frequently eliminated, partially or wholly. When the accommodation is not controlled, the suppression again recurs. This is a facultative type of foveal suppression and is presumed to be an escape from an annoying fixation disparity for fine detailed seeing. When suppression is eliminated at the uncontrolled or "accommodative" angle of deviation, relative accommodation can be established and a permanent normal binocular status achieved.

CONCLUSIONS

Rigid control of the accommodation during suppression therapy in tropia can shorten the treatment period by many months. Experience and observation of the suppression patterns in relative accommodation enable the orthoptist to know when and how long to maintain the accommodation at rest with convex lenses, when and how long to stimulate it with concave lenses.

If a foveal suppression is not noted or remains uncorrected in heterophoria, the end-results of orthoptics from the patient's viewpoint will be similar to the following: "It didn't do much good," or "My eyes don't feel any better," or "My eyes felt better before I did the exercises."

Foveal suppression is the big stumbling block to development of normal relative accommodation. The loss or interruption of relative accommodation makes foveal suppression possible. When relative accommodation is attempted in the presence of foveal suppression, discomfort arises. It is only when the foveal suppression is eliminated that relative accommodation is comfortable.

Recognition of the need for developing normal relative accommodation in all heterophoria and tropia patients will make a good prognosis an assured conclusion to the case, with permanent results and a comfortable patient. Normal, single binocular vision without glasses is frequently a pleasant by-product.

The necessity for research in establishing a "norm" of relative accommodation for persons with normal binocular vision is apparent. The need for sufficient and rigorous measurements applied to relative accommodation is clear. Its role in the totality of the accommodative process should be clarified. Such a research project would need a team of workers: ophthalmologist, neurophysiologist, physicist, and orthoptist.

CLINICAL EXPERIENCE WITH ISOFLUROPHATE AS AN AID IN ORTHOPTIC TREATMENT

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We have found in our survey of 100 cases that the use of isoflurophate (Floropryl; DFP) in the treatment of accommodative esotropia may be more successful if an attempt is made to increase and stabilize the relative fusional divergence with orthoptics. In the treatment of accommodative esotropia, the purpose is to give the patient comfortable single binocular vision or to alleviate as many symptoms as possible without the aid of glasses. It is my hope in presenting this paper to show why Floropryl* was used by citing several cases.

In 95 cases of accommodative esotropia seen in our clinic, Floropryl was prescribed. Nineteen patients had a normal accommodation-convergence ratio, but weak fusional divergence amplitudes. In 40 cases, it was prescribed to eliminate use of bifocals or to avoid prescribing them to correct an abnormal accommodation-convergence ratio. It was prescribed to ascertain the mechanical and accommodative factor in 36 cases. Since the greater number of patients seen in our clinic have accommodative esotropia with an abnormal accommodation-convergence ratio, our greatest interest lay here.

Of the 40 patients with an abnormal accommodation-convergence ratio who were given Floropryl, only one did not develop a normal accommodation-convergence ratio (table I). This patient developed iris cysts less than a week after Floropryl therapy was started; medication was discontinued at once and the wearing of glasses was resumed. The remainder of the 39 patients are being seen in the clinic from once monthly to once every three months. None of these 39 patients are now using the miotic; in all cases it has been discontinued for at least six months, in some, for as long as a year and a half, and all still maintain their normal accommodation-convergence ratio.

When we work with accommodative esotropia, we are attempting to improve the relative fusional divergence, which is the amount of divergence that can be exerted to overcome excessive convergence brought about by excessive accommodation and still maintain single clear vision. Low amplitude of relative fusional divergence is a characteristic common to all accommodative strabismus, but it is more pronounced with the abnormal accommodation-convergence esotropia. That is, the esotropia is greater at near than at distance and the amplitude of relative fusional divergence, which is present at near, is insufficient to mask the excessive convergence. The result is an esotropia with an abnormal accommodation-convergence ratio. In these patients with such abnormal accommodation-convergence ratio, the amount of hy-

*Ophthalmic ointment, 0.025 per cent isoflurophate, Merck, Sharp & Dohme.

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TABLE I
RESULTS OF TREATMENT WITH DFP

Normal accommodation-convergence ratio with sufficient relative fusional divergence amplitudes	15
Developed normal accommodation-convergence ratio	39
Reaction to Floropryl	2
Developed fusion (esophoria) with surgery and Floropryl	19
Failed to return	3
Still Esotropia	17

permetropia present seems to be insignificant, usually from one to three diopters. Therefore the urge to accommodate, as well as the hypermetropia, must influence the accommodation pattern.

In reviewing the history and records of these patients, we found that a large number of them had been wearing bifocals two or three years or longer. Many of these patients were doing dissociation exercises and had been for years, continuing to work regularly at home with exercises. Slowly, progress was being made. A greater number of these patients had good amplitudes of absolute divergence with little, if any, relative fusional divergence or relative accommodation. That is, when 20/80 print or smaller was required for reading at near range, excessive accommodation called forth excessive convergence and accommodative esotropia resulted. An interesting fact about these patients with poor relative fusional divergence was that they all preferred to "blur" and see a single image rather than to see clearly and experience diplopia. In many of these cases it was almost impossible to elicit diplopia, as the blur had become so tolerable to the patient that it was a fixed pattern of seeing.

It was observed that among those patients whose relative divergence increased in proportion to the relative accommodation, the normal accommodation-convergence ratio remained fixed even after the Floropryl was discontinued. But in those whose relative accommodation did not increase along with the relative divergence, the normal accommodation - convergence ratio was somewhat unstable, i.e., the tendency to overconverge when excessive accommodation was exerted was a rather spasmodic or intermittent pattern at near.

Case 1: (Before Floropryl) Female, aged 6 years, had been wearing bifocals for one year, and still had intermittent esotropia with diplopia appreciation. Her corrected vision: R. E., 20/30+3; L. E. 20/30+2. Her prescription: R. E., +1.25 sphere; L. E., +1.25 sphere, with a +2.50 add. With glasses at distance, there was esophoria of 10△ when accommodating. There was an esophoria-tropia (blurred) of 40△ on accommodating at near with glasses. With the aid of the bifocals at near, the intermittent esotropia was 14△ when accommodating. Without glasses, at distance the esotropia was 40△ and at near 60△ when accommodating. Diplopia was recognized with and without correction at distance and at near. Amplitudes of fusion on the troposcope at distance were convergence 25△ and divergence to zero. Little suppression was noted. At near with glasses on the troposcope, only momentary fusion was present. Only two weeks after beginning use of the Floropryl ointment, the intermittent esotropia with bifocals had become an esophoria of 8△, and through the upper segment at near the patient could now maintain straight eyes and read large print. As the frequency at which the ointment was used decreased, the intermittent esotropia which had occurred when the patient looked through the upper segment at near returned, but the esophoria with bifocals remained. For several months no ointment was used, and the normal ratio remained. At times when reading Jaeger 1 (20/20) at near, intermittent esotropia resulted. The bifocals have not been removed as yet, because the squint does not seem to be stable. Relative divergence exercises were given, using base-in prisms while accommodating on small print at near, but the hyperactivity of the patient resulted in almost no amplitude of reserve. Any emotional upset seemed to cause a setback. We felt that in view of all factors, this patient had progressed fairly well. Perhaps

the strength of the bifocals can be reduced in the near future.

Since dissociation exercises did not seem to alter the abnormal accommodation-convergence ratio in most cases, it was felt that use of isoflurophate might be justified—that a stimulus to diverge as well as to accommodate might be initiated. The ophthalmologist prescribed 0.025 per cent Floropryl ointment for a period of one to four months, to be used every night for two weeks, then gradually extending the frequency to once every five days or less.

Case 2: White female, aged 6 years, had been wearing bifocals for 1.5 years. She could blur and straighten through the upper segment, and occasionally read Jaeger 5 for near, but appreciated diplopia when the eyes crossed. Eyes were always straight through the bifocals. R. E. +1.50; L. E. +1.50 sphere with +2.00 add. Corrected vision in each eye was 20/20. Esophoria at distance with glasses was 8△ on 20/40 print. At near, 20△ intermittent esotropia was evident when accommodating on 20/30 print. Through the bifocal lenses prescribed, the esophoria was 8△ while accommodating. Without glasses, the patient had an intermittent esotropia of 10△ and 20△ while accommodating at distance and at near respectively. The amplitudes of divergence and convergence at distance and near on the troposcope with correction were within normal range. Little suppression was noted. Two weeks following use of the ointment, the glasses had been removed temporarily by the ophthalmologist, and the patient could now read 20/30 print at near without glasses. Immediately relative divergence exercises with base-in prisms were given for home exercise. The patient was able to build up a reserve of divergence and convergence both at distance and near. Ointment was discontinued at the end of two months, at which time the measurements were intermittent esotropia 8△ at distance; esophoria 8△ on Jaeger 3. In two weeks the bifocals were removed and the distance correction was also reduced. Prescription was R. E. +1.00 sphere; L. E. +0.75 sphere. On the last visit (one year later) vision was 20/25 in each eye; esophoria 5△ with glasses at distance; esophoria 12△ with glasses at near. On the troposcope the patient had excellent amplitudes at distance and near.

With the advent of isoflurophate, the question arose as to the significance of iris cysts following the application of the miotic. Fewer patients who were using the ointment only every other night developed cysts than those using it every night for a weekly period. Only two patients had to discontinue the miotic because of reduced visual acuity and complaints of nausea or brow pain. Because of the possibility of iris cysts, patients were seen by their referring ophthalmologists at least once every two weeks as they continued with their work in orthoptics.

Immediately upon nightly instillation of the Floropryl, these abnormal accommodation-convergence ratios began to "disappear." As soon as the patient was adjusted to the Floropryl, orthoptic exercises to increase the relative fusional divergence were begun. A thorough examination was given the patient by the ophthalmologist, as well as by the orthoptist, before and after the administration of Floropryl. Diplopia awareness was essential before Floropryl was given. If the esotropia, measured while fully accommodating, was greater (at least 10 diopters) at near than at distance, if the full atropine correction had been given, and if the esotropia decreased an appreciable amount or disappeared with the aid of more plus add (bifocals) at near, Floropryl was given instead of trial bifocals, which could be given in the future if the Floropryl did not help.

Case 3: White male, aged 6 years, R. E. +3.00 sphere; L. E. +3.50 sphere. Corrected vision, 20/25 each eye. Esophoria with glasses at distance, 6△; intermittent esotropia with glasses when accommodating at near, 20-25△. The patient could blur and straighten at distance and near, and readily recognized diplopia. He could read only 20/200 print at near and maintain single vision. He had good amplitudes of convergence and divergence on the troposcope, at distance and near. Two

weeks after use of Floropryl ointment had been prescribed, the vision in each eye with glasses was 20/25. Esophoria with glasses at distance was 8△; esophoria with glasses at near, when accommodating, 8△. Prism relative divergence at distance and near with glasses, 14△. Amplitudes were much improved on the troposcope at distance and near. The frequency of the ointment was reduced. Two months later, without having had any ointment for two weeks, his measurements were essentially the same. No bifocals were given. His accommodation-convergence ratio was normal, and when seen on last visit, his esophoria for distance and near was about the same as previous measurements. Without his glasses, he had 25△ of intermittent esotropia, reading 20/80 to 20/30 print at near and distance.

Dissociation exercises are most helpful. Certainly we have many patients (those with normal accommodation-convergence ratios) in our clinic who are responding to this type of treatment, but it is rather hard at times to maintain the interest of the child, as well as of the parent, if progress from time to time cannot be seen. Since relative fusional divergence is stimulated with the application of the miotic, the patient with an abnormal accommodation-convergence ratio often experiences for the first time in his life, the ability to maintain straight eyes with clear vision, even without the aid of bifocals or perhaps without corrective lenses. Such an experience in many cases has stimulated a desire by the patient to work diligently with the relative divergence exercises at home.

For many patients with a normal accommodation-convergence ratio, dissociation training may still be the best method. Occasionally we found a few patients who, after extensive orthoptics, reached a period of status quo—they were able to maintain straight eyes most of the time when accommodating but were sometimes intermittent. Floropryl was given to stimulate divergence.

Case 4: White female, aged 7 years, R. E. +3.50 —0.50 x 3; L. E. +3.25 — 0.25 x 3. Corrected vision each eye, 20/30. Esophoria at distance with correction, 8△; esophoria, intermittent at near with correction, 20△. Without correction, distance and near esotropia, 30△. Near point of convergence, 70 cm. Range of fusion on the troposcope with correction at distance and near was only fair. Dissociation exercises were begun—diplopia awareness, framing, and anti-suppression exercises. Finally, after months of this type of treatment, no amplitude of relative divergence was stimulated. The intermittent esotropia still persisted, especially when accommodating. The angle of squint at times seemed to increase, yet foveal suppression was almost absent. Two weeks following the use of Floropryl, there was equal vision in the two eyes, 20/25; esophoria measured 8△ with glasses at distance and at near when accommodating. Without glasses, the intermittent esotropia at distance with glasses was 16△, and at near, 8 to 10△. Glasses were removed for all distance work and for one hour a day when reading. Six weeks later: visual acuity was equal in each eye and esophoria with glasses at distance and near 10 to 14△ on 20/30 print. Relative prism divergence at distance and near was 16△ on 20/30 print. The patient was instructed to work at home with base-in prisms for distance and near. Six months later the measurements were essentially the same. At this time the patient could hold the eyes straight without glasses, and always appreciated diplopia when crossed.

As the frequency with which ointment is used is diminished, the patients begin wearing minus clip-ons, beginning with 0.50 diopters in strength until the end point is reached —double vision. The more minus the patient can tolerate, the more stable will be the ratio of accommodation-convergence, especially in patients who originally have had an abnormal accommodation-convergence ratio.

In some cases it was found that the patient had not been given atropine cycloplegia for full correction of the hyperopic refractive error. It was felt that Floropryl every other night might help his intermittent esotropia. In such instances, glasses may have to

be removed for distance work while the ointment is being used. If the patient wears the full lens correction while on Floropryl therapy, an esotropia at distance sometimes results because of the overaccommodation to "clear" the "blur" which is caused by the Floropryl.

It must be understood that a longer follow-up is necessary to determine the results of treatment with isoflurophate in accommodative esotropia, especially in patients with an abnormal accommodation-convergence ratio. Isoflurophate aids in shortening the overall period of treatment in the abnormal accommodation - convergence ratio as compared to dissociation exercises, for it usually helps to normalize the accommodation-convergence ratio. Relative divergence is stimulated and the interest of the patient is maintained by the progress.

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THE TREATMENT OF EXOTROPIA

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NEARLY all aspects of divergent deviations have resulted in divergent opinions. This is true both of discussions concerning etiology and of those regarding the proper methods of treatment. A review of the literature reveals many points of disagreement.

One of the most fundamental points of disagreement is that concerning the existence or nonexistence of a divergence center. Cogan[3] feels that the so-called divergence paralysis syndrome is suggestive of the existence of a divergence center and that this center may be closely associated anatomically with the convergence center. This feeling is based on the occurrence of alternating divergence and convergence in some migraine attacks and with alternating palsies of convergence and divergence in Wernecke's disease. Sugar[11] believes that there is a divergence center located near the sixth nerve nucleus. Scobee[9] contended that divergence is merely a relaxation of convergence and that there is no need for the existence of a divergence center. Adler[1] summarizes the arguments pro and con quite concisely and refers especially to Bruce's article in favor of the existence of an active divergence center.[2] Bruce believes that if divergence were merely a matter of convergence relaxation, in other words, a passive function, the eyes would diverge in complete muscular relaxation. Furthermore, in such a function the eyes should diverge more rapidly at the beginning of divergence than at the end. Such variation in the speed of divergence does not seem to exist. If we think along logical lines, we should expect each function or action to have corresponding antagonistic function. Logically, one would expect to find such an important function centrally represented along with its antagonist, convergence.

If divergence is not an active function, it must be produced by a combination of factors such as the contraction of elastic tissue and the divergent position of the orbital axes (about 25 degrees). Divergence would be accomplished when the counteraction influence of convergence is diminished or abolished. This theory assumes that the so-called divergence paralysis is actually convergence spasm.

This brings up the question: Is there such an entity as divergence paralysis? Like the arguments for and against a divergence center, this question has produced endless arguments, none entirely conclusive. However, the fact that normal excursions of the eyes are possible in "divergence paralysis" would seem to suggest the existence and involvement of a divergence center. Certainly the full excursion of the eyes would seem to rule out a bilateral sixth nerve paralysis (Costenbader[4]).

I do not find any real agreement as to just what is signified by the commonly used term *divergence excess*. The fact that such a term implies an

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active function probably has persuaded some to use other terms. It has been called intermittent exotropia by many, and others have used the terms *periodic exotropia* (Bielschowsky, *neuropathic exotropia* (Worth[8]).

I like the following terminology of Costenbader,[4] and I have used this classification in grouping divergence strabismus.

I. Comitant exotropia
  A. Intermittent
    1. Convergence insufficiency
      a. Accommodative type (myopia, presbyopia)
      b. Toxic type (neurasthenia, illness, etc.)
      c. Secondary to divergence excess
    2. "Divergence excess" type
    3. Combined "divergence excess" and convergence insufficiency
  B. Constant—secondary to
    1. "Divergence excess" with convergence insufficiency
    2. Congenital and adult "dissociation" (one or both eyes blind or grossly different)
    3. Anatomical exotropia (such as occurs in hypertelorism)
    4. Consecutive exotropia
II. Non-comitant exotropia (including "postoperative")
III. Combined

This classification is taken directly from Costenbader without modification. I feel that it is the most logical and clear cut in our present state of knowledge concerning the basic physiology of the divergence function and its anomalies. Furthermore, it offers a logical classification on which we may base our various treatments.

The intermittent group comprises the great majority of divergent deviations, and it is in this intermittent group that we should expect to achieve our best results, for these patients already have attained single binocular vision, even though they fail to maintain it all the time, and have developed varying degrees of fusional amplitude. The age at which these deviations may occur varies with the type.

The convergence insufficiency type without significant divergent deviations at distance is not noted in very young children. As a rule it is not noted until the child is well along in school, often in high school or even older. It is in the older groups, of course, that a demand is made on convergence power, for it is the time when the individual is beginning to do more and more close work for longer periods. These young people have good vision in each eye and, aside from their difficulties with near vision, their binocular cooperation is good. This is to be expected, for the onset of these difficulties occurs long after the age at which binocular cooperation is developed. The deviation is greater for near than for distance, the near point of convergence is remote and prism convergence is poor for both distance and near. Prism divergence may not be remarkable unless secondary to a divergence excess.

A temporary convergence insufficiency may also be associated with poor health, excessive general fatigue or any condition affecting the general physical condition of the patient at any age. I think all of us have had a patient who, having suffered recent severe illness or undergone a major operation, has developed signs and symptoms of convergence insufficiency. In such cases the symptoms usually disappear when the patient regains his good health and so require little attention from the ophthalmologist or orthoptist. Aside from these, where our services are little needed, the convergence insufficiencies offer a fruitful field for our therapeutic efforts and should yield good results.

Of prime importance is adequate correction of any refractive error.

Often full correction—in some, overcorrection—of myopia will suffice and one should not institute any other treatment until this treatment has been given a reasonable trial. Extremely high hypermetropia or astigmatism should be corrected. I can recall an eight-year-old boy whom I saw because of his poor school work. He showed a marked convergence insufficiency and a refractive error under atropine of 10 diopters of hypermetropia in both eyes. He was given a plus 8.00 lens for either eye and a few months later was doing well in school and had good convergence. With the error uncorrected, he was unable to see clearly at near and made no effort to converge as it gave him no reward. When glasses alone prove inadequate, convergence insufficiency offers what we feel is the best field for effective orthoptic treatment.

Knapp[6] has stated that he has not needed to operate on a patient with convergence insufficiency, but I believe that high degrees of convergence insufficiency are benefited by resection of the medial recti.

Some convergence insufficiencies are secondary to an uncorrected divergence excess. The best treatment is correction of the primary condition, the divergence excess. Our procedure initially is a bilateral recession of the lateral recti. If necessary, one may give convergence exercises after correcting the divergence excess, but not before. If, convergence exercises are given preoperatively without adequate results and surgical correction of the divergence excess is finally performed, the patient may be left with a convergent squint. It seems logical to correct the primary anomaly first, and often this will be sufficient.

The straight-forward divergence excess cases would seem to offer a good field for complete cure when treated adequately, yet the results are often unsatisfactory. Patients in these cases are frequently seen early in life. The mother brings the child to the ophthalmologist with the complaint that one eye "drifts out at times." Frequently, when first seen the child shows no manifest deviation. As the child is often very young and difficult to examine, one may fail to elicit the deviation on examination. However, the mother who complains that her child's eye "drifts out at times" is almost always correct, and eventually the conscientious ophthalmologist will detect the deviation. The doctor who examines such a patient carefully will find an exophoria or exotropia for distance with good near binocular cooperation. The near point is good and prism convergence for near is normal; prism divergence at near may be normal or a little increased. At distance the prism divergence may be difficult to measure because of suppression but, when measured, will be excessive. The child may fuse or alternate at distance. Vision is usually good in both eyes.

At the Boston City Hospital we consider that these cases are almost always surgical problems. We like to operate on them early, but often this is not possible. If the deviation is not too frequent and is rather fleeting in duration each time, the parents are often reluctant to consider surgical correction. We do not attempt to influence them, especially in the mild cases, for the child is developing his binocular cooperation the greater part of the time and we feel there is no great urgency. However, we are all aware of the tendency for divergent deviations to increase with passage of time and eventually most will require surgical correction.

In the older child, the development of a secondary convergence deficiency

is an indication for surgical intervention. Of course the nonsurgical measures must not be neglected. Myopia should be fully corrected, or overcorrected; hyperopia should be corrected only enough to ensure clear, comfortable vision, if such correction is needed; and any significant astigmatism should be corrected. Suppression, if it is present for distance, must be overcome. Any significant vertical anomalies should be surgically corrected. One must be aware here of the A and V syndromes and their significance. In pure cases of divergence excess, early and adequate recession of both lateral recti is usually needed. When one asks what is an adequate—or safe—lateral rectus recession, one again receives widely divergent opinions.

Knapp[6] has stated that recession of the lateral recti should not exceed 7.5 mm. Cushman and Willard[5] give 4.0 as a minimum and 7.0 mm. as a maximum. Scobee[10] believed that one should not recess the lateral rectus more than 5.0 mm. Urist,[13] on the other hand, feels that one can safely recess up to 10.0 mm. Our experience has been disappointing with the lesser amounts of recession.

Because of the position of the eye in the orbit in relation to the origin of the muscles, the lateral rectus has a rather long arc of contact with the globe as it passes around it to reach its insertion. Tour and Asbury,[12] while discussing primarily the medial rectus, show very lucidly how the effective point of action of the muscle is at its tangential point of contact with the globe. My old and revered friend, Walter Lancaster, demonstrated this many years ago. Because of its rather extensive wrap-around effect, the effective limit for the lateral rectus is much more posterior than that of its companion medial rectus. Hence, to be effective a recession of the lateral rectus must be generous and, as corollary, one may be generous in recessing it and still be on safe grounds. I like to do 8 to 10 mm. recessions bilaterally in all but small divergence excess cases.

One must, of course, keep in mind the anatomical relation with the inferior oblique in doing large recessions. Our experience has been that one is not likely to obtain an overcorrection, undercorrection being most likely. Less than full recession has been very disappointing in our clinic.

For the patient with a so-called combined divergence excess and convergence insufficiency we like to do a full recession of both lateral recti. If this is inadequate, we do a resection of both medial recti later. One may ask if we get in trouble with our full recession of the lateral recti. We have found overcorrection to be rare; when it does occur, it offers, like all overcorrection, a difficult problem. We do not have a satisfactory answer to overcorrection at present.

When a patient has equal vision in both eyes and concomitant exotropia, I prefer symmetrical simultaneous surgical correction. The results, variable though they may be, are better than with monocular surgical procedures, although in smaller degrees of deviation I may operate on only one lateral rectus. Lee and O'Brien[7] advocate recession of the lateral rectus and resection of the medial rectus for both divergence excess and divergence excess combined with convergence insufficiency. They do not feel that it is necessary to differentiate the two types. In the lower degrees they do not resect the medial rectus. In their hands this gives good results.

The constant exotropia presents a somewhat different situation. In our

clinic we feel that these are all surgical problems. Often the condition has been present for a long time and frequently there may be a marked amblyopia. Many of these patients with constant exotropia are adults in whom the problem is chiefly cosmetic. We tend to treat these by recessing the lateral rectus and resecting the medial rectus on the deviating eye. If the deviation is secondary to prior surgical correction of an esotropia, we follow the same procedure of recessing the lateral rectus and resecting and advancing the medial rectus. These secondary cases are often problems for which we should like to have better solutions than are available at present.

In conclusion, we must repeat our opening statement that divergent deviations produce divergent opinions. We are gradually improving our knowledge as various people present their opinions, and perhaps in the future our combined experience and knowledge will lead to lessened divergence of thought and lessened divergent deviations.

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INTERMITTENT EXOTROPIA

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SINCE it is beyond the scope of this paper to discuss intermittent exotropia exhaustively, we would like to stress certain aspects in its management that we believe to be important.

1. *Glasses.* The correction of refractive errors has a negligible effect on the amount of the deviation for distance, but it may increase the ability of the patient to keep the deviation latent. The full correction of significant myopic and astigmatic refractive errors and the balancing of any anisometropia may profoundly improve the near measurement by alleviating or preventing a secondary convergence insufficiency. We have given up the practice of strongly overcorrecting with minus lenses up to three diopters as ineffectual. We now use this only to balance low amounts of hyperopic anisometropia or to change hyperopic astigmatism into myopic astigmatism.

2. *Orthoptics.* Occlusion is routinely used in the treatment of amblyopia and to treat suppression passively when necessary. In older children, active preoperative antisuppression training is preferred when this is practical. Absolute vergence training is avoided except as a step towards training relative vergences. We stress divergence more than convergence.

3. *Measurements.* In the successful treatment of cases of intermittent exotropia, preoperative measurements are of paramount importance. One must strive to elicit the maximal deviation to be corrected. Routine prism cover test measurements at 20 feet and 13 inches, using a muscle light for a fixation target are frequently inadequate to bring out the latent deviation. Measuring the deviation while the child is looking out the window at an isolated object (over 200 feet away) is one way to bring out the deviation, particularly on a sunny day. A second method consists in asking the child to read Snellen letters or identify figures while the deviation is being neutralized with prisms. Both methods may reveal that a moderate exophoria on a muscle light at 20 feet is in reality a much larger exotropia.

The measurements for near are also important in that a deviation of approximately the same magnitude as the distant measurement indicates a secondary failure of convergence. Again, measuring the deviation while the patient is maintaining clear vision is more reliable. If the near measurement is a small exophoria or esophoria, the effect of +3.00 spheres is informative. If the divergent deviation does not significantly increase, a surgical operation on the lateral recti may produce a disfiguring esotropia for near postoperatively, as the patient has an anomaly of convergence plus his divergence excess.

The near point of convergence offers worthwhile information if it is properly taken. The patient must be

trying his utmost. Then the notations of proximal, proximal but poorly maintained, and remote give reliable evidence of the status of convergence.

There is no doubt about the frequency with which a vertical deviation is associated with a divergent deviation. When this is merely a hyperphoria of the nondominant eye on distant fixation and is not present for near, we ignore it as being due to dissociation. If it is due to one or more paretic vertically acting muscles, we treat it surgically.

In recent years interest has focused on those cases showing a significant change in the amount of horizontal deviation in the eyes up and eyes down positions of gaze. It is considered routine for a patient with divergence excess to show a slightly larger deviation in eyes up, and for a patient with convergence insufficiency to show a larger deviation in eyes down. To qualify as being anomalous, the change in deviation must exceed fifteen diopters and must be measured while the patient is maintaining clear vision. The anomalous deviations are called the A and V phenomena, in which the letters indicate graphically the form of the deviation. In V exotropia, the deviation is at least fifteen diopters more in eyes up; whereas in A exotropia the deviation is at least fifteen diopters more in eyes down. These syndromes comprise between ten and twenty-five per cent of motility cases. The etiologic basis is in dispute. Our opinion is that they are due to an imbalance in the vertically acting muscles so that the adducting effect of the vertical recti fails to counteract the abducting effect of the obliques. This overaction of the obliques or underaction of the vertical recti may be slight, although the resulting incomitancy of the horizontal deviation is large.

4. *Time to treat.* We feel strongly that these cases do not improve spontaneously and that the majority of them progress. Therefore, the gain in waiting for the child to be sufficiently mature for more accurate evaluation is offset by the further development of suppression and possible failure of convergence. Surgical correction should be done as soon as an accurate diagnosis is possible. Our best and most enduring results have been in the age group from two to four years.

5. *Treatment.* The only treatment is surgical correction. If the ophthalmologist takes the time to explain the process, stating that it will not permanently improve but generally tends to become more manifest with the development of deep suppression and a loss of binocular cooperation, the parents will often accept the need for early intervention. The surgical therapy for exotropia must be bold, for it is essential to correct the deviation fully, or, in the absence of secure binocular vision, the deviation will tend to recur. If feasible, we prefer bilateral simultaneous symmetrical operations.

6. *Postoperative care.* This is most important, as many potentially good results may be lost during the immediate postoperative period. Frequent postoperative visits are essential so that treatment for any eventuality can be promptly instituted. If a significant undercorrection is present, little can be done except to plan for another operation. If the deviation is still predominantly for distance, cautious recessions, taking care not to set the muscle back further than 8 mm. from the original insertion, can be done. This may be the ideal situation for marginal myotomies, but I have no personal experience with them. Slight undercorrections with the distant

measurement under 10 diopters may respond well to convergence training. During this period, an overcorrection with minus lenses is helpful. If secure fusion can be established, the result may be maintained permanently. The prescription of base-in prisms to make the patient artificially esophoric has sometimes been helpful.

Small initial overcorrections are desirable in the surgical treatment of exotropia. The patient should be observed carefully so that he does not overconverge in seeking the visually silent area of the optic disc. Isoflurophate (Floropryl) is quite helpful in these cases, as it eliminates or minimizes accommodative convergence, making it more difficult for the patient to maintain this overconvergence. If relative divergence has been stressed preoperatively, the patient can usually fuse in comfort and a lasting cure results. Large overcorrections usually occur when an A or V phenomenon is not diagnosed preoperatively or when the new horizontal alignment brings out the imbalance of the vertical muscles on the horizontal deviation. In this case surgical correction of the resulting A or V esotropia is indicated. The final type of overcorrection can be avoided by taking the preoperative measurement for near with +3.00 spheres. This detects an anomaly of convergence. In these cases Sugar's procedure of recessing one or both medial recti at the same time the lateral recti are recessed would be the procedure of choice. Fortunately, we haven't encountered the need for this yet.

In conclusion, if care is taken to measure the patients completely to elicit the full deviation and to detect hidden A or V phenomena, if preoperative orthoptics stresses antisuppression and relative divergence and avoids absolute convergence training, and if one is lucky enough to make the proper correction, intermittent exotropia can be cured.

The cases cited are merely illustrative and unfortunately not entirely representative (table I).

These patients are between 2.5 and 4 years of age. All showed a slight overcorrection in the early postoperative period. The short follow-ups are admittedly inadequate.

TABLE I
CASES OF INTERMITTENT EXOTROPIA CORRECTED BY BILATERAL RECESSION

PATIENT	AGE (YEARS)	DEVIATION	AMT. OF RECESSION	RESULT	FOLLOW-UP NO. OF YEARS
L. H.	4.0	XT 25 X(T)′ 10	4.5 mm.	Sl. S & S′	4.0
J. P.	2.5	XT 35 X(T)′ 35	5.0 mm.	3X 6X′	4.0
D. R.	2.0	XT 40 X(T)′ 30	6.0 mm.	0 & 0′	2.0
M. S.	3.0	X(T) 30 X(T)′ 30	5.0 mm.	Sl. S & S′	2.0
O. G.	2.5	X(T) 30 X(T)′ 30	5.0 mm.	0 7X′	4.0
M. F.	3.5	XT 60 X(T)′ 60	7.0 mm.	0 S′ 2	4.5
A. B.	3.0	XT 45 X(T)′ 15	6.0 mm.	0 & 0′	1.5

S=esophoria for distance; X=exophoria; O=orthophoria; ′=deviation for near.

Our undercorrections are too numerous to list. Many of the undercorrected cases have been lost to follow-up or the parents of such children are still too pleased or too pessimistic to plan for the recommended further correction.

Significant overcorrections have not been a problem, although we have three of them under observation at the moment. However, with the aid of Floropryl and red filter antisuppression training, all are improving and it is doubtful whether reoperation will be necessary.

The following case reports are illustrative of how orthoptics can help. In these cases the building up of a good range of relative fusional divergence plus the use of Floropryl or bifocals turned the tide towards relative orthophoria and fusion rather than a search for the silent area of the blind spot.

The treatment of A and V exotropia has been omitted purposely, as that is a subject in itself.

CASE HISTORIES

Case 1

A. E. was first seen by the ophthalmologist at the age of 6.5 years. The parents noticed the right eye turned out at the age of 2 years. The condition improved but the deviation recurred when he was 6 years old. The exotropia measured 45 diopters when the patient looked out the window in sunlight, 15 diopters intermittently for distance, and orthophoria for near. With +3.00's, the patient had an intermittent exotropia of 20 diopters for near vision, with the left eye preferred. There was no vertical deviation and the near point of convergence was unlimited. Patching and antisuppression training were carried out for one month before surgical correction, which was a 5 mm. bilateral recession. One week after operation the measurements were intermittent esotropia of 10 diopters for distance, and of 15 diopters for near, with the right eye preferred, and the patient said he saw double. Floropryl ointment, 0.025 per cent, every other night was prescribed, and six weeks later this patient showed orthophoria for distance and 3 degrees of exophoria at near. The Floropryl was reduced to twice a week, and four weeks later the patient had orthophoria for both distance and near. The Floropryl was further reduced to one application weekly, and four weeks later the orthophoria had been maintained for distance and 2 diopters of esophoria at near had developed. Floropryl was stopped. One year later orthophoria had been maintained for both distance and near.

Case 2

M. G. was first seen by the ophthalmologist at the age of 9 years with a history of the right eye turning out since she was a year old. Her exotropia measured 40 diopters at 200 feet, XT 30 X(T)′ 20 with the left eye preferred. The near point of convergence was 50 and there was no vertical deviation. Refraction under cycloplegia showed O.D. −1.25 20/30, O.S. −1.25 20/20. The patient was given nine sessions of orthoptics and the left eye was occluded before surgical correction, at 6 mm. bilateral recession. One week after the operation she had orthophoria for distance and 8 degrees of esophoria for near. Three weeks later she was orthophoric with an esophoria of 2 diopters. Three months later she had an esotropia of 12 diopters for distance, and of 20 diopters for near. She was given orthoptic training to stress divergence with plus correction for near. Two years postoperatively esophoria measured 4 diopters for both distance and near, and the patient was wearing −2.00 spheres, with visual acuity of 20/20 in each eye.

ORTHOPTIC TREATMENT

The current regimen of orthoptic training in cases of intermittent exotropia is six to nine training periods scheduled preoperatively. All preoperative training is directed to the elimination of suppression, both peripheral and foveal, and to the development of relative vergences. The postoperative training is, of course, determined by the surgical results.

Peripheral suppression is attacked with home exercises. The patient is trained to appreciate diplopia on an object at any distance with either eye fixing. This is accomplished with a diplopia exercise, first using a color difference and then omitting it, and

it is encouraged by occlusion. Work on foveal suppression is done in the office on the major amblyoscope with foveal size targets and utilizing the crossing technique. This training is done at the divergent angle. Also, red filter work at home is suggested for foveal suppression.

After the patient is aware of the position of his eyes, the framing exercise is taught, employing physiologic diplopia. The patient is asked to frame large objects at first and to progress gradually to smaller and smaller objects until pictures the size of the fovea are used. The development of relative vergences is started immediately after foveal suppression is minimized. The patient learns to overcome prism base in and prism base out and to maintain clear vision on 20/20 print both at distance and near. Relative vergences are made more secure by bar reading. After an amplitude of relative convergence of 25 and a relative divergence of 10 to 20 are established, the patient is considered to be ready for surgical correction.

Postoperative training, if needed, may consist of red filter glasses, clip-on prisms, plus or minus lenses, or a short period of training to stabilize relative convergence or divergence.

In case 1 the patient received the orthoptic training just described. Following the operation for correction of exotropia, we prefer to see a slight esodeviation, such as this patient shows; therefore, no postoperative training was required.

In case 2 the patient received the same preoperative orthoptic training. Following the surgical correction, she had an esotropia of 12 diopters for distance and an esotropia of 20 diopters for near with double vision. At times the esotropia was as high as 30 diopters, and we feared she might stabilize on the blind spot. Her myopic correction was immediately removed and +2.50 clip-on lenses were given for near work. With the +2.50 lenses she was able to keep the deviation latent most of the time. Then intensive training was begun to increase the amplitude of relative divergence. Bar reading was resumed, first clearing large print and slowly progressing to 20/20 print. When the patient was able to bar read 20/20 print with the +2.50 lenses, +2.00 lenses were given and the procedure repeated. We continued changing the clip-on lenses by half a diopter every three or four days until she was able to go back to her myopic correction and retain orthophoria while accommodating.

Not all patients are amenable to orthoptic training, but when training is begun emphasis is placed on the elimination of foveal suppression and on the development of relative vergences.

In conclusion it would seem that orthoptics is a helpful adjunct in the management of exotropia.

ORTHOPTIC TRAINING—HOW LONG?

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OPHTHALMOLOGY is one of the most accurate branches of medical science. There is practically no guessing in our diagnosis. Therapy is specific with little exception, and the prognosis is accurate. There are a number of eye diseases which cannot be cured, but with the precise diagnosis one can foretell the poor prognosis in these incurable cases.

On the other hand, there is a regrettable uncertainty and delay in the prognosis of disturbances involving single binocular vision. The average patient is not interested in the diagnosis; he frequently does not even ask what the trouble is. He wants to know, many times even before the examination starts, whether he can be helped. It does not enhance the reputation of a therapeutic procedure when, after ten to twenty sessions, the patient is told that his ailment cannot be cured.

No wonder that modern orthoptics at its tender age is still far from maturity. There are, of course, good reasons why one cannot foretell how the treatment of sensory adaptations of a heterotropic eye will turn out. Several obstacles have to be cleared, such as amblyopia, suppression and anomalous retinal correspondence, before the ideal aim, single binocular vision, can be restored; and then fusion has to be developed. But by now orthoptics has passed the teen-age period and should discard the excessive optimism of youth. It should be in the third stage that every therapeutic approach reaches sooner or later; namely, to distinguish precisely and early when it can be used with advantage to the patient. It is just as much in the interest of the patient as it is in ours to increase the accuracy of prognosis and reduce to the minimum the number of dissatisfied patients. This is a hard task in orthoptics because of the various types of strabismus and defects of binocular vision, the youth and immaturity of most of the patients, and, what is perhaps the most important in every goal in life, motivation, which is so many times absent in very young patients.

I would like to discuss the duration of treatment in the various sensory complications of strabismus.

Amblyopia

Poor vision in a heterotropic eye, with seemingly normal fundus, does not always mean amblyopia. It may mean also a fine macular defect that is a congenital malformation, which may show itself only by the absence of the macular and/or foveal reflex, a so-called macular aplasia, which is easily overlooked. Von Noorden and Burian[8] made the very interesting observation that the amblyopic eye fixates better in dim light. However, when organic changes are present, fixation gets worse in decreased illumination. I am not aware that this differential diagnostic method has been clinically used.

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How long should occlusion be continued in order to erase amblyopia? Most of us agree that occlusion should be carried out so long as there is improvement. But how long is "so long"? If there is no improvement of vision after three or four weeks of constant occlusion of an eye which has central fixation, should occlusion be continued? Capobianco[3] states that one or two months of complete occlusion without any improvement in visual acuity is enough.

How should one treat amblyopia of the nonfixing or eccentrically fixing eye? According to Bangerter,[1] the eye with nonfoveal fixation should be occluded, because the eccentric fixation is established, and by occluding the fixing eye the eccentric fixation would be even more stabilized. This is a principle in Bangerter's pleoptic routine. The false macula is dazzled by a strong light and the anatomical macula is stimulated. Cüppers' method, euthyscopy, is a refinement of this procedure by which the whole area around the anatomical macula is depressed.

Vision in an amblyopic eye of 20/200 or better can more easily be improved than vision in an eye with deeper amblyopia. Bangerter[1] divides his amblyopic patients into three groups: vision 1/10, that is 20/200 or less; vision 1/10 to 3/10; and vision better than 3/10. In the first group that interests us, there were 139 such eyes. Out of these 139 eyes, 60 (43 per cent) ended with vision of 3/10 or less.

In this latter group, with such poor vision the restoration of binocular single vision is highly questionable. These 139 persons had an average of 48 treatments. Bangerter,[2] in rechecking his visual results after an average of three and a half years, found that vision had deteriorated in 27 per cent of the patients, which leads us to wonder whether this type of treatment should be adopted. Yes, perhaps, in patients whose vision is not more than 20/200 to 20/300 after a month of occlusion. Would a therapeutic procedure be widely accepted if the result was poor in 43 per cent except in lifesaving procedures, when a small percentage of success has to be accepted? We have to wait for more reports of experts in this field before indications of pleoptics and euthyscopy can be established.

Now the next step, *suppression*. How long should one try to erase suppression. Woodward,[9] states:

> Before suppression can be eliminated, the eyes must (1) be straight under some or all circumstances, and (2) have equal or nearly equal visual acuity.
>
> It is a waste of time to treat suppression when the eyes have no opportunity to work together in daily life, since suppression is a binocular phenomenon, evincing itself only when both eyes are open. If suppression is overcome and the eyes are not straight at least intermittently, there results either an annoying diplopia or a re-established suppression.

It is a common experience that by making the visual axis of the two eyes surgically parallel, binocular single vision may re-establish itself if vision is nearly equal in the two eyes.

The essayist's experience has been similar to that of Cooper[4] in nonaccommodative comitant esotropia and comitant exotropia. From 1949 through 1955, only surgical correction and occlusion were practiced when the vision was less than 20/40 in the poorer eye. This gave an observation period of at least three and a half years. Most patients since 1956 had also had orthoptic treatment and were not included in the tabulation.

Out of 221 patients who were asked to reappear for checkup, 144 either came or sent answers to the questionnaire. Eighty-one patients, 37 per cent, actually appeared in the office. Of these 64 had originally had esotropia (table 1) and 17 had had esotropia (table 2). Of the 64 persons with esotropia, 25 had functional cure, 18 had a good cosmetic result (which means esotropia of less than 10△), and 21 had a poor result (heterotropia of over 10△). Costenbader[5] differentiates four groups in his "Classification of Cures," following treatment of strabismus. Patients considered having a functional cure in this table belong in cure grades 1 and 2 of Costenbader's classification. Fifty-two patients with esotropia answered the questionnaire, which consisted of three questions: eyes straight, 26; reasonably straight, 22; not improved, 4. If the patient says *straight*, it does

TABLE I
NONACCOMMODATIVE COMITANT ESOTROPIA, 116 PATIENTS
TREATMENT WITH OCCLUSION AND SURGERY FROM 1949 TO 1955

AGE AT TIME OF SURGERY (YEARS)	RE-EXAMINED IN 1959			QUESTIONNAIRE ANSWERED		
	FUNCTIONAL RESULT	COSMETIC RESULT	POOR RESULT	EYES STRAIGHT	REASONABLY STRAIGHT	NOT IMPROVED
0-3	3		6	2	6	
4-5	10	10	8	14	8	1
6-7	7	6	3	4	5	1
8-12	4	1	3	3	1	1
Over 12	1	1	1	3	2	1
Total	25	18	21	26	22	4

TABLE II
COMITANT EXOTROPIA, 28 PATIENTS
TREATMENT WITH OCCLUSION AND SURGERY FROM 1949 TO 1955

AGE AT TIME OF SURGERY (YEARS)	RE-EXAMINED IN 1959			QUESTIONNAIRE ANSWERED		
	FUNCTIONAL RESULT	COSMETIC RESULT	POOR RESULT	EYES STRAIGHT	REASONABLY STRAIGHT	NOT IMPROVED
0-3						
4-5				1		
6-7	1		2	1		
8-12	3		1	1	2	
Over 12	4	1	5	2	2	2
Total	8	1	8	5	4	2

not always mean functional cure, but the chances are that some of these had functional cure. Reasonably straight means that the patient is satisfied from the cosmetic standpoint.

In the exotropia group, out of the 17 who were re-examined, 8 had functional cure, one had a good cosmetic result, and 8 had a poor result —exotropia was more than 10△. Eleven persons answered the questionnaire: 5 have straight eyes; 4 have reasonably straight eyes; and 2 have not improved.

It is probably not of great importance to have a perfect functional result in the extreme periphery of the field of gaze. In experiments conducted by the author[6] in 1924 on the actual field of gaze,* it was found that the eye seldom moves more than 20 degrees. If one has to look to right or left 50, 60 or 80 degrees, most of the movement is compensated for by the movement of the head; the eye doesn't move under everyday requirements more than 20 to 25 degrees. It is of little or no significance if there is incomitance at 20 or more degrees from the primary position.

In some patients the fusion will be restored rather rapidly if the vision is nearly equal in the two eyes and the motor anomaly is satisfactorily corrected. It is just a question of consolidating these results. In another group, training taking even longer won't lead to a satisfactory result. Eustis,[7] states:

> If normal fusion is elicited, a patient is seen for twelve visits and then given a rest. If, on the other hand, normal fusion is not elicited by the sixth visit, I discontinue active orthoptic training . . . .

*Actual field of gaze is the field which the eye has to cover after the head has made the compensatory movement. For instance, when looking from the primary position to 50 degrees to the left, the head will move 25 to 30 degrees to the left. The remaining 25 to 20 degrees of field which the eye has to cover is the actual field of gaze.

It is difficult to know when to stop the fusional training and when to continue. It would be very beneficial to ophthalmology and the stature of orthoptics to be able to make the prognosis after a few treatments.

As for abnormal retinal correspondence there are diverging views not only concerning its treatment but even regarding its nature. In treatment, the modern view seems to tend in the direction of early surgical intervention. That means early restoration of the parallelism of the visual axes and that the macula be given the chance to take over the work. This probably is a field in which pleoptics or euthyscopy should be tried in stubborn cases.

If we can be more selective and can make an early prognosis in the treatment of sensory complications of strabismus, chances are that the work of the orthoptist will diminish. However, there is a new field for the orthoptist. It is generally accepted that restoration of binocular single vision is more difficult if the abnormal binocular habit has persisted for several years. Therefore, screening of preschool children for anomalies of binocular single vision is highly desirable. Too often the individual parent with untrained observation has to decide whether medical advice is necessary. Although the ophthalmologist should be the first to be consulted, routine screening at the preschool level could be performed by this specially trained group of individuals competent in the handling of children, as well as in their knowledge of this kind of ocular problems.

SUMMARY

Orthoptics has reached a stage where it should get rid of unnecessary and time-consuming therapy, which often ends with poor results. If ple-

optics and euthyscopy can assure a larger number of permanent results, they should be used where the orthodox methods fail. But as it stands now, it takes much time to carry out these treatments. This is a plea to ophthalmologists and orthoptists to make the indications for orthoptic training more precise, selective and to eliminate unnecessary treatments.

Orthoptists may be of help in screening preschool children for anomalies of binocular single vision.

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OFFICE ORTHOPTICS

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ORTHOPTICS as we know it is practiced in hospitals, clinics, the home, the orthoptist's office and the ophthalmologist's office. The success of orthoptics depends on the orthoptist, the patient, and the doctor. The ophthalmologist's office is the ideal place in which the orthoptist, the patient and the doctor may accomplish their goal. The major part of orthoptics is still practiced under conditions outside the ophthalmologist's office. There has been a general shortage of trained personnel in this field. This shortage is being corrected somewhat by the training of more orthoptists; however, it is unlikely that there will be personnel available for every office within the foreseeable future.

The first essential of a good orthoptics department is a good orthoptist. There is some difference of opinion as to how much the orthoptic technician should be required to know. It would seem, that the more she knows, the better. The responsibility of the differential diagnosis is not hers, but she should know the underlying principles of such a diagnosis. She sees the patient for much longer periods than the physician does, and this should make is possible for her to contribute much to the diagnosis. If she has an understanding of anatomy and physiology along with knowledge of the mechanics of orthoptics, she should be a better orthoptist.

The orthoptist is a teacher and needs all of the qualifications of a good primary school teacher. She must have a basic love of humanity. Loyalty, truthfulness, good manners, emotional stability and a professional personality are essential characteristics.

The basic education varies considerably in orthoptic technicians. A nurse's training is highly desired, especially for the type of office employee to be discussed in this paper.

The ability to use a typewriter is helpful. The technician should be able to collect data and make reports. She should be able to take pictures of patients to show how the eyes look before treatments and after treatments. Equally as important is a need to organize and run the department efficiently and as any successful business should be run.

The alert, intelligent, inquisitive patient is the one best suited for orthoptic training. Some selection is necessary in any training program. Office orthoptics allows for a wide evaluation of patients. The borderline orthoptic patient can be referred to the orthoptist in order that she may judge whether the child is old enough, cooperative enough, and intelligent enough, and whether his malfunction will be responsive to orthoptics. This referral and evaluation can be done with little or no extra cost to the patient. Often, no additional office visit is necessary.

This paper does not deal with the obvious uses of orthoptics, such as

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measurements of phorias and tropias, fusion studies, occlusions and preoperative and postoperative training. The less frequent uses of orthoptics and the borderline orthoptic problems are to be discussed.

Many patients with vague complaints such as burning eyes, feeling of eye strain, or poor focusing, can be evaluated by the orthoptist before cycloplegic examination is done. We are then better able to evaluate the total findings without need for a return visit.

Findings at refraction are often borderline as to whether symptoms will be relieved by glasses. Orthoptic evaluation can be done and recommendations made with more assurance that the right suggestion is being made.

Occasionally, we use orthoptic training on a trial basis. If there is very little abnormality of fusion or muscle balance but the symptoms suggest some such abnormality, we may recommend orthoptic exercises on a trial basis. Such a procedure can be followed closely and the patient checked often by the ophthalmologist.

Orthoptics has some value in the office as a psychological factor. There are many patients who feel that their eyes are the cause of all their symptoms. Anxiety, fear, apprehension, tension, general fatigue, pregnancy, or some other systemic condition may exist to cause the symptoms. A complete orthoptic examination including a refraction, visual field study, funduscopic examination, and study of intraocular tension may convince the patient that he has had a very thorough examination. When the doctor says that the eyes are not the cause for the symptoms, the patient accepts the statement, feeling that the examination has been very complete.

There is still another group, I hope not too large, in which orthoptics in the ophthalmologist's office is better than sending the patient to an outside office. This use is a psychological one —or, shall we say, a placebo. This should not be mistaken for the commercial use of eye exercises. Certainly, we do not approve of the use of orthoptics to relieve the patient of his excess finances. There are a few patients in which the power of suggestion can be used with good success. Most of those patients have some anxiety or tension with headaches or eye strain. The patient needs and must have something to blame for the trouble. That same patient needs something to give credit for making him feel better.

It is interesting to note the increase in certain symptoms with changes in the weather. A drop in the stock market may produce extra business for the ophthalmologist because of so many patients with headaches. Family troubles and emotional strain of many types can produce symptoms that are to be investigated by the ophthalmologist.

New glasses, tint in the glasses, new frames, a change of lenses or eye drops may do away with the symptoms with very little physiological basis for such help. This is the type of patient in which orthoptic exercises may be used for psychological or placebo reasons. Occasionally, I refer a patient to the orthoptist with the statement that exercises are to be given for placebo reasons. I am sure a few patients have been helped by such treatments. The original cause for the symptoms may have been relieved during the few weeks of treatment. The stock market may have gone up. The vacation time may have been changed. At least the

patient is relieved and may believe that the exercises were helpful. Such a patient may say, "See, I told you there was something wrong with my eyes."

A second member of a family, or a friend of another orthoptic patient may feel a need for exercises. He may feel that his eyes and his symptoms are the same as those of his friend or relative. His friend or relative was improved by orthoptics; therefore, he may feel sure that orthoptics will help him. In certain fixations, we tell the patient that we do not see any reason for him to have exercises but that he may take a few exercises to see whether they will help. I am often surprised to see the willingness with which the exercises are accepted and to see the apparent improvement which some patients show. We must not allow such patients to become orthoptic cripples and depend on exercises every time they get into a stress situation.

Orthoptics may be used for the harmless malingerer. The child who wants glasses may refuse to see the letters on a chart. A few exercises on the troposcope may convince the child that there is nothing wrong with his eyes.

My point in stressing these rather vague and indefinite uses of orthoptics is to point out that while many of them are feasible as office procedures, they would not be practical if the patient had to be referred to an outside office or clinic. If the complete workup can be done in one office, the patient is saved considerable time and expense.

Some reading difficulties of a rather vague nature are improved by orthoptics. Remedial reading and speed reading may reach a plateau in which very little is gained from the training. Careful orthoptic examination may show some fusion difficulty or muscle imbalance. Orthoptic training may give definite aid in attaining a greater speed level.

Another advantage of having orthoptics available in the office is in the evaluation of patients that have been examined by the telebinocular or some other testing apparatus used in schools and for examinations in industrial organizations. The orthoptic examination helps in making the report and in giving suggestions and advice to the patient.

The doctor is an essential part of a good orthoptic program. The doctor must believe in orthoptics. The attitude that orthoptics is a necessary evil and only being done because colleagues are doing it, is a poor one.

The doctor should have a basic knowledge of what is to be accomplished and should be able to advise and direct the training. Many ophthalmologists do not have the necessary understanding of orthoptics because it was not included in their formal training. Other doctors neglected to take advantage of that training when it was available to them.

We should acquaint ourselves with the newer concepts and be prepared to discuss the treatments with the patient, with the parents, and with the technician. The ideal arrangement is for the doctor to have the complete eye findings and the orthoptic evaluation for consideration before a decision is made regarding the treatment to be carried out. With the orthoptist in the ophthalmologist's office, those findings can be readily available. The probable training necessary and the course to be followed can be discussed by the doctor and technician in the presence of the patient and the parents. A misunderstanding regarding

the number of treatments or frequency of treatments is less likely with this type of discussion. The doctor can visit the orthoptics department. He can observe the patients getting treatments and keep in close contact with what is being done. This makes the orthoptist a more integral part of the setup, and the situation is not so much one of sending the patient to a laboratory.

Time is valuable in any busy ophthalmologist's office. The orthoptic technician can be of great help as a timesaver, especially with the small children. I use my orthoptist to acquaint the children with the office, to check their vision, to get the preliminary findings, and to prepare the children for the more formal examination. Many children refuse to talk or to be examined until they become acquainted. Rarely does a child refuse to respond after a few minutes with Mickey Mouse and Minnie Mouse and other interesting toys in the orthoptics room. The child need not be an orthoptic problem in order to enjoy the pleasant environment and orientation session in our orthoptics room, for our orthoptist helps by taking a history, checking the visual acuity, and measuring the muscle balance before I see any small child.

Each patient has a psychological problem which must be handled with care and understanding. During the treatments, the technician may learn more about the family background. She may learn of emotional or financial problems that influence the treatment. New problems can be discussed at once with the doctor.

The orthoptist can help make orthoptics acceptable to the patient, to the parents, and to the public. She can help by word of mouth in the office. She can have relative freedom under the doctor's sponsorship to discuss orthoptics with nursing groups, parent-teacher groups, and other civic and educational groups.

There are very few offices with enough orthoptic patients to keep the orthoptist busy full time. The willing technician can perform other duties in a busy office. Our orthoptist is a nurse. She helps in our operating room. That gives her the chance to see what is found at the operation and what procedure is done on the patients whom she has worked with. Her presence in surgery has led to much less confusion. It is difficult to find nurses that understand the routine for eye surgery in a general hospital because of the frequent change of personnel.

Parents are happy to know that their child will have the orthoptist present in the operating room. The child is usually happy to see the familiar face. The doctor may not look as familiar in the operating room as he did in the office.

Our orthoptist helps with other technical procedures. Visual fields, visual screening, diplopia tests, and Lancaster red-green tests are often done by her.

We often find our orthoptist helping at the appointment desk. She assists with minor operations, helps with intramuscular injections, and pinch-hits in any department when not busy at orthoptics.

Under the Code of Rules Governing Department of Certified Orthoptists, the new orthoptist is fairly restricted. The best field for expansion of orthoptics is in the ophthalmologist's office. It is my belief that many more ophthalmologists could use an orthoptist to good advantage. Many doctors think that they cannot afford this specialized service. I do not be-

lieve we can afford to be without this service.

The convenience of having an orthoptist in the office is paramount. If the orthoptist is willing to accept other duties, such as taking visual fields and visual checks, and to help with the office routine, then many more ophthalmologists will realize the importance and advantages of an orthoptist in the office. Patients will gradually become more familiar with the uses of orthoptics. Ophthalmology will benefit and orthoptics will gain the stature that it deserves.

THE A AND V SYNDROMES

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THE increased interest in vertical defects associated with, or secondary to, horizontal deviations has, in the past century, produced great diversity of opinion as to the primary cause and the approach to corrective surgical procedures.

In 1855, von Graefe[5] first described the condition in which an upshoot of the eyes in upward deviation is observed. He later attributed the cause to an overaction of the inferior oblique muscles.

Duane[4] observed the relationship between the horizontal deviation for near and distance as of diagnostic importance. In his classification of esotropia which was greater in distance vision than at near originated the term *divergence insufficiency*. He recognized the importance of vertical deviations in this group, and suggested that in some cases the horizontal deviation may be secondary to a vertical muscle defect.

Marlow[8] proved by a study of his prolonged occlusion test that normal eyes which were dissociated for a varied period of time exhibited hyperphoria. He stated:

> Prolonged occlusion developed a reversion to the infantile state, that state out of which binocular vision has been developed.

Berens[1] states:

> Concomitant hypertropia of a high degree is rarely found as a primary condition in which no involvement of an elevator or depressor may be found, and . . . in noncomitant vertical anomalies, paresis of an elevator or depressor may be seen.

Urrets-Zavalia[12] stresses the importance of observing the eyes in the direct up and direct down positions of gaze in diagnostic evaluation, and notes that in certain cases of combined vertical and horizontal deviations, the horizontal component is fully concomitant in lateral gaze and the vertical component completely noncomitant between direct up and direct down gaze.

He attributes elevation of the eyes in adduction with a marked degree of divergence in elevation and some convergence in depression to overaction of the inferior oblique muscle, irrespective of the type of lateral deviation. He associates slight facial malformations, mongoloid obliquity and narrowing of the palpebral fissure with some of these cases. Convergence in elevation and divergence in depression in which a downshoot of the adducted eye may be observed is due to contracture of the inferior oblique muscle. Facial asymmetry, hypoplasia of the malar bones, slanting of the palpebral fissure and uneven contour of the lower lid may be contributing factors.

Chavasse[7] expressed the opinion that the difference between elevation and depression may be due to the relative position of the insertion of the oblique muscle. Scobee,[9] on the other hand, states:

> Hyperphoria may be the result of too high attachment of one or both medial or lateral rectus muscles, abnormal attachment of the vertical recti, the obliques or both.

He referred to the common observation that the lateral deviation may dis-

appear after correction of the vertical deviation by vertical placement of prisms. This opinion supports the belief that the lateral deviation is more frequently caused by hyperphoria than is hyperphoria by lateral disturbance.

White and Brown[14] showed in a study of 1062 cases that heterotropia with combined vertical and horizontal components is found as frequently as is heterotropia in which only one component is present. White[13] found 98 per cent of the cases with hyperphoria to be due to a weakness of one or more of the elevators or depressors, associated with overaction of the yoke muscle or contracture of the direct antagonist. Brown[2] attributes the basic cause of incomitancy in the direct up and direct down gaze to the vertically acting muscles and applies the theory so concisely stated by Urist.[11]

In direct upward gaze with the elevators contracting, increased adduction could be caused by overaction of the superior rectus muscles whose secondary action is adduction or by underaction of the inferior obliques whose secondary action is abduction. In downward gaze with the depressors contracting, the increased abduction could be due to the overacting superior oblique muscles whose secondary action is abduction or underacting inferior rectus muscles whose secondary action is adduction.

In upward gaze with elevators contracting, increased abduction could be due to overacting inferior oblique muscles or underaction of the superior rectus muscles. In downward gaze, the depressors contracting, the increased adduction could be due to overaction of the inferior rectus muscles or underaction of the superior obliques.

Urist[10] stresses the diagnostic importance of the straight up and straight down positions of gaze and bases his classification of the various types on the action of the eyes in vertical and horizontal gaze. His classification is divided into four groups and may be described as representing the A and V syndromes.

Group I. Esotropia with Bilateral Elevation in Adduction—so-called V Esotropia

The esotropia is greater in direct depression than in direct elevation and greater at near than for distance. Left hypertropia is demonstrated in dextro-elevation and right hypertropia in levo-elevation. The convergence near point is good. Some degree of fusion may be present. Urist attributes the apparent overaction of the inferior obliques to the primary overaction of the medial rectus muscles.

Group II. Esotropia with Bilateral Depression in Adduction—A Esotropia

The esotropia is greater in direct elevation than in direct depression, and greater for distance than at near, or the same for near and distance. Relative elevation in abduction, in which elevation of the right eye in gaze up and right, and elevation of the left eye in gaze up and left may be seen. The convergence near point ranges from 30 to 90 mm. Fusion in some degree may or may not be present. The primary cause of the apparent overaction of the inferior oblique muscles is primary underaction of the lateral rectus muscles.

Group III. Exotropia with Bilateral Elevation in Adduction—V Exotropia

The exotropia is present for distance and direct upward gaze with exophoria at near and direct downward gaze. Right hyperphoria is observed in gaze to the left and increases in elevation to the left; left hyperphoria

is seen in gaze to the right and increases up and right. The convergence near point varies from 20 to 50 mm. Fusion is present. The apparent overaction of the inferior oblique muscles is due to a primary overaction of the lateral rectus muscles.

Group IV. Exotropia with Bilateral Depression in Adduction—A Exotropia

The exotropia is greater in direct depression than in direct elevation, and for near than for distance. Right hypertropia in gaze to the right increases in dextrodepression and left hypertropia in gaze to the left increases in levodepression. The convergence near point may vary from good to poor. Fusion may or may not be present. This final group is attributed to underaction of the medial rectus muscles.

In summarizing Urist's classification, increased divergence in the distance and direct upward gaze may be attributed to a defect of the lateral rectus muscles in exotropia and the medial rectus muscles in esotropia. Increased divergence at near and in the direct downward gaze may be due to a defect of the lateral rectus muscles in esotropia and medial rectus muscles in exotropia. He has shown in a large series of cases in which a surgical operation was performed on the horizontal muscles that the A and V syndromes are correctible to a great extent.

Jampolsky[6] in his extensive study of exotropia with vertical noncomitance considers the primary cause to be secondary involvement of the oblique muscles in the divergent eye, and in alternating exotropia to be symmetrical bilateral overaction of the oblique muscles. Overaction of the superior obliques frequently associated with the A exotropia is attributed to paresis of the inferior rectus muscles. He favors tenotomizing the superior obliques as opposed to resecting the inferior rectus muscles, and found that the former surgical procedure reduced the lateral deviation by approximately 45 prism diopters between direct up and direct down gaze, while the latter accomplished a change of only 18 prism diopters. Overaction of the inferior oblique muscles in the V exotropia is thought to be due to weakness of the superior rectus muscles. The favored surgical procedure is tenotomy of the inferior obliques, which was found to decrease the exotropia in direct elevation by approximately 15 prism diopters with little change in direct elevation.

Costenbader[3] reports that an operation performed on the horizontal muscles may improve the deviation in the primary position but little improvement is noted in the direct up and direct down positions. Resection of the lateral rectus muscles and recession of the inferior obliques resulted in some improvement in the V esotropia, while resection of the lateral recti with advancement of the inferior obliques resulted in considerable improvement in both components in the A esotropia. Resection of the lateral rectus muscles and recession of the inferior obliques improved the V exotropia to some extent. The A exotropia is only occasionally improved by tenotomy or recession of the superior obliques. Costenbader also reports a case of V esotropia following a bilateral recession of the medial rectus muscles which he corrected by resecting the lateral recti and recessing the inferior rectus muscles of each eye.

From this brief resume, it is readily seen that the etiology in the A and V

syndromes remains controversial, as does the choice of surgical correction.

While the underlying cause of these phenomena is quite beyond the scope of the orthoptic technician, she can, however, play an important role in assessing accurately the quantitative versional movements by various orthoptic tests. She may thus be of great help to the ophthalmologist in making his diagnosis and a decision regarding the correct surgical procedure.

In view of the significance attached to vertical defects combined with horizontal deviations, the preliminary screening in all cases of strabismus should include versional movements in the direct up and direct down positions, as well as the cardinal positions of gaze. Should noncomitance between direct elevation and direct depression be evident, accurate measurements by prism and screen cover test in these and cardinal positions are requisite.

Careful screening should be done for facial asymmetry, which may lead to apparent rather than real defective movement of the eye, facial malformations, and abnormal head positions which can mask diplopia in some fields.

The vertical deviation may not be evident in the primary position until the eyes become dissociated by the screen test. The horizontal deviation may be observed to increase in elevation or depression and the vertical deviation in lateral rotation and lateral upward gaze. If the eyes are straight in the direct up or direct down gaze, fusion may be present in the straight position.

In young children whose attention span is limited, casual observation of the child before attempting the examination is helpful in determining if and when the eyes are straight and which eye deviates. Quantitative estimation of the misalignment of the eyes and displacement of the corneal light reflex in the nonfixating eye are used to assess and classify the deviation. The photographic method of measuring the corneal light reflex in the versional fields of gaze is of value.

It is obvious from the variability found in the case of A and V syndromes that the orthoptic technician must know what to look for in order to assess the different groups accurately. Orthoptic treatment is limited to establishing fusion and amplitudes in the direction in which the eyes are straight as an adjunct to surgical correction.

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SOME UNUSUAL MOTILITY PROBLEMS OF NEURO-OPHTHALMOLOGICAL IMPORTANCE

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SEVERAL neurological problems of unusual interest may be encountered in the orthoptic clinic. As the orthoptist most commonly encounters children in the younger age groups, the following neuro-ophthalmologic abnormalities seen in children were selected for discussion:

1. Unusual types of nystagmus
2. Internuclear ophthalmoplegia
3. Congenital ocular motor apraxia
4. Ataxia-telangiectasia

The importance of recognizing these cases more than offsets their rarity. Indeed, their early recognition may be life saving in certain instances. The point to be stressed is that they are indicative of disease of the central nervous system, and that prompt neurological and neurosurgical evaluation is mandatory. Associated signs, other diagnostic criteria, and therapy will be minimized in this discussion in order to stress the characteristic eye features that may be seen by the orthoptist.

I. NYSTAGMUS

Nystagmus is an involuntary to-and-fro oscillation of the eyes. From this large subject, concisely reviewed by Rucker[6] in 1953, seven unusual types will be mentioned.

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A. *Vertical Nystagmus*

While vertical nystagmus is properly a sign of disease in the posterior fossa, a common exception to this rule warrants emphasis. If a child with vertical nystagmus is seen, the first question which should be asked is whether or not the child is on antiepileptic or other medication. Dilantin and barbiturates both can produce virtually any type of nystagmus.[8] However, the most common type of barbiturate nystagmus is a rapid, small-amplitude vertical nystagmus present on upward gaze, but absent in the primary position and on downward gaze. In addition, there is usually increased horizontal endpoint nystagmus on looking to either side. The rapid component of the latter is toward the side of directed gaze (rapid phase to left on levoversion, and rapid phase to the right on dextroversion).

Nystagmus due to drugs must be differentiated from that due to intracranial disease. This can be simply done if the prescribing physician can discontinue or markedly reduce the medication, as drug-induced nystagmus will disappear with two or three days as a rule, and always in less than a week.

Another type of vertical nystagmus is noteworthy. Vertical nystagmus usually becomes more marked as the eyes are elevated. However, in cases of brain stem compression at a low level (foramen magnum), the nystagmus is often more marked on down-

ward gaze.[2] This type of downward-gaze vertical nystagmus has been seen in several patients with platybasia (congenital defect at the base of the skull). In any patient with this type of vertical nystagmus, special roentgenographic studies for platybasia are indicated.

B. *Uniocular Nystagmus*

The three commonest causes of this very unusual phenomenon are spasmus nutans, multiple sclerosis, and congenital amblyopia of one eye. Spasmus nutans characteristically occurs during the first several months of the child's life, and clears by age two. The nystagmus is rapid and pendular in type, and may be accompanied by head nodding. According to Cogan,[1] spasmus nutans is the commonest, if not the only, cause of unilateral horizontal nystagmus in infancy. On the other hand, it may be bilateral, but in such cases it is often asymmetric, that is, it may be seen in one eye on looking in one direction, and in the other eye on looking in the opposite direction. A slow vertical oscillation of an amblyopic eye has been seen in two cases of monocular nystagmus. In one of these, the loss of vision was due to an optic neuritis many years before. In the second case, a young woman in her twenties had a slow vertical oscillation of one eye behind a pinhole lens (20/25 vision) and shortly thereafter developed tragic evidence of acute multiple sclerosis.

C. *Rotary Nystagmus*

Rotary nystagmus indicates disease of the vestibular apparatus or its connections. It is seen not infrequently in multiple sclerosis, but because of the extreme rarity of this disease under the age of 10, any child with rotary nystagmus should be suspected of harboring a tumor involving the vestibular nuclei in the floor of the fourth ventricle.

D. *Dissociated Nystagmus*

A very rare phenomenon is the occurrence of nystagmus of different types in the two eyes. A 14-year-old girl has been seen with simultaneous vertical nystagmus in the right eye and horizontal nystagmus in the left eye, due to a midbrain tumor. After a decompression operation, the dissociated nystagmus disappeared. Cerebellar abscesses and other mass lesions in the posterior fossa have produced such nystagmus. On the other hand, it may also occur as a congenital abnormality.[2]

E. *Seesaw Nystagmus*

In 1914 Maddox[5] described a patient with a bitemporal hemianopia, in whom the two eyes would rise and fall in opposite directions like a seesaw. I have encountered two cases of seesaw nystagmus; both of the patients also had a bitemporal hemianopia. The following pattern is characteristic of this type of nystagmus:

1. The nystagmus is pendular, or nearly so, and the eyes are dissociated so that they rise and fall alternately as a seesaw.
2. Associated conjugate torsional movements are present.
3. The amplitude of the nystagmus is less on looking up and greater on looking down.
4. The seesaw phenomenon is most easily seen by having the patient look down and then observing induced movements of the lids.

A ten-year-old girl recently seen with seesaw nystagmus had "twitching of the eyes" as her only complaint. Nevertheless, she was found to have a bitemporal hemianopia, reduced vision and optic atrophy on the right as well. At operation an intra-

cranial suprasellar epidermoid cyst was removed (a benign tumor), with prompt cessation of the nystagmus and improvement in vision. This was the first histologically verified case of seesaw nystagmus to our knowledge, and the satisfactory response to therapy indicates the importance of diagnosis despite its great rarity.

F. *Nystagmus Retractorius*

Nystagmus retractorius consists of irregular jerks of the eyes backward into the orbit when the patient attempts to look in one or the other direction, usually up. It is caused by lesions in the midbrain, especially in the vicinity of the sylvian aqueduct. Other associated features include pupillary changes, spasm of convergence on attempted elevation of the eyes, clonic convergence spasm, and paralysis of vertical gaze. In two cases recently seen through the courtesy of Dr. Zieper, retraction of the lids was noted with this syndrome. Horizontal optokinetic nystagmus responses were intact in both cases, and it was of interest that with targets rotating up, an intact response was seen, whereas with targets rotating down, it was possible to bring out the retraction nystagmus.

G. *Convergence Nystagmus*

Disjunctive nystagmus of convergence also occurs with lesions in the midbrain and is likewise quite rare. It may be present along with the other features of the sylvian aqueduct syndrome (Koerber-Salus-Elschnig).[4]

II. INTERNUCLEAR OPHTHALMOPLEGIA

Internuclear ophthalmoplegia is a characteristic disturbance of ocular motility of definite value in topical and etiologic diagnosis. Although not commonly encountered in children, it may occur at any age. Classification of this entity has been difficult because of varying terminology in the literature. Thus, classification of internuclear palsies by Lutz and by Cogan are virtually exactly opposite and often confused. The Lutz classification is quoted by Duke-Elder[3] as follows:

> In anterior internuclear palsies, the externus on the side of the lesion functions normally (or restrictedly), but the contralateral internus is paralyzed for conjugate movements towards the side of the lesion, and at the same time functions normally in convergence. In posterior internucleus palsies, on the other hand, both internal recti function normally in convergence and in lateral conjugate movements, but the externus on the side of the lesion is paralyzed for conjugate movements.

The Lutz-type posterior internuclear ophthalmoplegia may thus mimic a simple sixth nerve palsy, and abduction of the eye must occur with labyrinthine stimulation if the former is to be differentiated. As Cogan considered that no unequivocal case of the Lutz posterior type had been reported, he proposed a different classification based on the presence or absence of convergence and of associated conjugate gaze palsy. Thus, in the Cogan classification, in anterior internuclear ophthalmoplegia there is impairment of convergence associated with paralysis of the medial rectus on horizontal conjugate gaze toward the side opposite the lesion. Posterior internuclear ophthalmoplegia, on the other hand, is that condition in which convergence is unaffected despite paralysis of the medial rectus in conjugate horizontal gaze. It should be stressed that in the Cogan classification, there is weakness of the ipsilateral medial rectus muscle on horizontal gaze in both types of internuclear palsy, and there is characteristically a predominantly monocular nystagmus in the abducting eye. The latter feature has led some authors to employ the term "ataxic nystagmus" for this syndrome.

The best way to illustrate the confusion arising between the two different classification of internuclear palsy is to use a hypothetical case.

A man seen by Dr. Frank Walsh in Baltimore complains of diplopia. Levoversion is performed normally, but when he looks to the right, the left medial rectus lags, while the right eye turns out normally but with some nystagmoid jerking. The left medial rectus functions well in convergence, however. Dr. Walsh, who uses the Lutz classification, reports to this patient that he has a right anterior internuclear ophthalmoplegia. However, this patient may desire another opinion; therefore he goes to Boston and is seen by Dr. David Cogan. Again, levoversion and convergence are intact, but when the patient looks to the right, the left medial rectus lags, while the right eye abducts well and again shows some essentially uniocular nystagmoid jerking. Dr. Cogan's report to this patient is that he has a left posterior internuclear ophthalmoplegia. If this patient had not been able to converge, but otherwise findings were identical, Dr. Walsh would have called this a right anterior internuclear ophthalmoplegia, just as he did in the first place, but Dr. Cogan would now call it a left anterior internuclear ophthalmoplegia.

Anatomic evidence favors the lateralization of the Cogan classification. Thus, in internuclear palsies in which the left medial rectus fails to function in conjugate gaze but does so in convergence, unilateral lesions have been found at autopsy in the left medial longitudinal fasciculus. However, the Lutz classification has probably been more widely employed. I have no preference for either classification but feel that such patients should be described with a definite statement as to which classification (Lutz or Cogan) is being used. Or, more simply, what is seen should be recorded and the terminology may thus be avoided. One can write that "on looking to the right, the left eye lags, but the left turns in on convergence," and no confusion can possibly arise.

The medial longitudinal fasciculus is the site of the lesion producing a paralysis of the medial rectus in conjugate gaze and yet sparing it in convergence. A unilateral internuclear palsy is most often seen with vascular lesions of the brain, and a bilateral internuclear ophthalmoplegia is virtually diagnostic of multiple sclerosis.

III. CONGENITAL OCULAR MOTOR APRAXIA

In this interesting condition, the child has lost voluntary and command movements of the eyes to either side, yet random movements are preserved. Vertical movements are executed normally. Such patients develop head turning as a compensating feature, and the head thrusts actually are the most striking clinical feature. The Roth-Bielschowsky phenomenon is a characteristic disturbance in which, along with a paralysis of voluntary conjugate gaze in one direction, the rapid phase of vestibular nystagmus is lost, but the slow phase is retained. Furthermore, on stimulation of the labyrinth ipsilateral to the paralysis of voluntary conjugate gaze, the slow phase is compulsory and cannot be voluntarily inhibited, so that a fixed position of the eyes results. Such an obligate turning of the eyes on rotation of the body (Roth-Bielschowsky deviation) is quite striking in children with congenital ocular motor apraxia. The orthoptist should be familiar with the "doll's head" phenomenon, as it is a simple test to perform in any person who appears to have a gaze paralysis.

If gaze remains on vestibular stimulation but is lost on voluntary and optokinetic stimuli, the condition is called a "pseudo-ophthalmoplegia" and the condition resembles the automatic movements of a doll's eyes, whence its name. A complete evaluation of such movements is available in Cogans' "Neurology of the Ocular Muscles."[1]

IV. ATAXIA-TELANGIECTASIA

An unusual association between Roth-Bielschowsky deviation and other interesting eye signs has been noted in the syndrome of ataxia-telangiectasia. This is a recently recognized familial disorder in which children have progressive cerebellar ataxia along with conjunctival telangiectasia. In a recent case, a typical pseudo-ophthalmoplegia was noted, as the patient could not turn her eyes on command but had briskly intact doll's head movements. Other characteristic features in this syndrome are (a) inability to execute voluntary gaze movements rapidly and smoothly on command, despite full excursions on casual gaze; (b) maintained contraversive deviation of eyes on rotation of the body; (c) reluctance to maintain eccentric gaze; and (d) occasional vertical nystagmus. The disorder is recognized easily on eye examination by the presence of conjunctival telangiectasia.[7]

SUMMARY

Several motility problems of neurologic significance may be seen in the orthoptic clinic, and their recognition is important despite their rarity. Some of these situations are described, and the ocular features that aid in their recognition are pointed out. These include vertical nystagmus, uniocular nystagmus, rotary nystagmus, dissociated nystagmus, seesaw nystagmus, nystagmus retractorius, convergence nystagmus, internuclear ophthalmoplegia, congenital ocular motor apraxia, and ataxia-telangiectasia. The orthoptist who detects one of these conditions and who is helpful in getting a prompt neurological evaluation of the patient is a valuable member of the medical team.

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ETIOLOGY OF ORTHOPTIC CASES

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WHAT caused Tommy's eye to turn? Can it be straightened? Naturally these are the first questions of an anxious parent.

"Cause unknown." Unfortunately this is the answer which is so often given to the inquiring parent instead of a clear explanation. This is particularly true in cases of strabismus, which, of course, are our primary concern.

To remedy any situation, the cause must be found and eliminated if possible. This holds true in the field of medicine, also. Not only is the treatment of the disease dependent on the diagnosis and discovery of the cause, but the recovery is thus determined. How then can a proper prognosis be made if the cause is unknown?

It is said that only 1.5 per cent (Dr. Burian states 4.0 per cent) of all children in the United States have strabismus. This is a small percentage, but how wonderful it would be to know that every last one of those cases could be accurately diagnosed and an equally correct prognosis made and achieved!

What information do we have on the etiology of these cases of strabismus? In the last three years we have given active orthoptic therapy to 236 patients. Out of this number, only 65 (27.5 per cent) gave any definite data on the child's history. The remainder come under the classification of "unknown."

Before we consider the tabulation of our cases, let us look at the information put forth by others. In a survey done by Scobee[3] with history given on 179 strabismus cases, the most frequent cause was "an injury" (not a fall). This was held responsible for 19 per cent, or 34 out of the total of 179. Twelve per cent, or 22, were said to be due to "a fall." In another study of 466 patients, strabismus was found to exist in the families of 41 per cent.

"Worth and Chavasse's Squint," edited by Lyle,[2] makes the following etiologic classification, which includes all types of cases.

I. SENSORY OBSTACLES

A. *External Obstacles.* Prolonged use of one eye, due to incorrect glasses or bandage necessary for treatment

B. *Dioptric Obstacles.* Interference with proper formation of dioptric images
   1. Uncorrected refractive errors
   2. Opacities, such as cataract

C. *Retinoneural Obstacles.* Defects and disease of the retina or optic nerve

D. *Proprioceptive Obstacles.* Defective muscle sense. This may occur as the result of a squint and be an added factor to consider in the treatment.

II. MOTOR OBSTACLES

A. *Mechanical Displacement of One or Both Eyeballs*
   1. "Space occupying" lesions of orbit or adjacent structure

2. Congenital abnormality of shape or position of orbit
3. Orbital injury resulting in damage to supports of eyeball, or organization of blood clot interfering with action of muscles

B. *Paralysis or Paresis of an Extrinsic Ocular Muscle*

1. Conditions affecting the muscle itself
   a. Congenital absence of a muscle, or congenital abnormalities of its insertion
   b. Injury to a muscle, particularly the lateral rectus
   c. Contracture of the antagonist of a paralyzed or incompletely exercised muscle
   d. Disease of muscle, as in exophthalmic ophthalmoplegia
2. Conditions affecting the motor nerve trunks of the oculomotor nerves
   a. Head injury, especially fracture at the base of skull. Immediate onset of palsy may be due to severance or bruising of nerve, or to pressure from hemorrhage. Delayed onset may be due to hemorrhage or sepsis.
   b. Inflammatory conditions, as meningitis
   c. Vasular disease, due to pressure by means of thickened artery or due to basal aneurysm
   d. Neoplasm, or tumor, putting pressure on or stretching the nerve.
3. Conditions affecting the nerve roots between nuclei and trunks
   a. Inflammation of brain substance due to encephalitis
   b. Vascular disease, as hemorrhage, thrombosis or embolism
   c. Neoplasm

   Note: In this area the nearness of nerve trunks of the cerebral nerves controlling ocular movements, Nerves III, IV, and VI, to the pyramidal tracts and to the facial nerve is important.
4. Conditions affecting the motor nerve nuclei
   a. Congenital aplasia of the nucleus
   b. Inflammation
      Acute: encephalitis, polioencephalitis, or effect of certain toxins
      Chronic: cerebral syphilis, etc.
   c. Vascular disease
   d. Neoplasm

C. *Decompensation of an Extrinsic Ocular Muscle Imbalance*

Usually this is intermittent at the beginning, becoming permanent, but it may occur suddenly.
An esophoria may "break down" and become a convergent squint.
An exophoria may "break down" and become a divergent squint.
A hyperphoria may "break down" and become a vertical squint.

III. CENTRAL OBSTACLES

A. *Hysteromalingering*

B. *Physical or Mental Trauma or Illness (Psychological Squints)*

This may change a latent into a manifest strabismus. Intermittent squint may be due to anger, jealousy, but this type *does not become constant when a latent deviation is not present.*

C. *General Hyperexcitability of Central Nervous System, as Undue Excitement, or Hypoexcitability, as in Lethargic States*

ACCOMMODATIONAL AND OTHER SQUINTS PRIMARILY RELATED TO THE STATE OF REFRACTION

There are two defects of accommodation in normal early infancy:

1. Dynamic defect—due to lack of full development of ciliary muscle until age two or three.

2. Static defect—due to hypermetropia, 4-5 diopters at age one year; takes eight years or more to disappear. Convergence power is developed fully before accommodation power is needed. Infant does not need and has no interest in making objects clearer and more definite.

Accommodational convergent squint may be due to (1) static defect of accommodation, as in moderate hyperopes; (2) relative defect of accommodation, as in children greatly interested in near work; or (3) insufficiency of harmonic reflex. (The harmonic accommodation reflex adjusts discrepancies between accommodation and convergence.)

Other types of squint related to refraction are (1) *convergent* strabismus of congenital myopia, in which the child can see objects at near, but distant objects are so blurred that there is no motivation to fuse; therefore he continues to converge; and (2) *divergent* strabismus of acquired myopia, which begins after the occipital accommodation reflex is established. Accommodation is relaxed, and so is convergence.

It must be remembered that "more than one factor may be operative in the causation of the squint in any given case."

In over 25 per cent of children who have strabismus, it has existed since birth. Birth injuries can be a frequent cause. If forceps were necessary, occasionally they have been applied incorrectly, which can cause damage to the extraocular muscles, particularly the lateral recti, by paralysis of the sixth nerve. Pressure on the infant's head during delivery results in multiple minute bleeding points in the brain in an estimated four out of ten births. It was mentioned previously that the percentage of strabismus in the child population is 1.5. There is a vast difference between 40 per cent and 1.5 per cent.

Let us consider the information that was obtained from our cases. We divided them into five groups in order of their freqeuncy: (1) inherited, (2) developmental or birth factors, (3) disease, (4) paralysis, (5) injuries.

1. More than a third of the total cases, 36 per cent, come under the inheritance group with known strabismus in the family. It is interesting to note that one patient was a twin, with the other child having no eye defect whatsoever. There was one other twin whose brother died at birth.

2. Developmental anomalies and birth injuries accounted for 18 cases, or 28 per cent.

3. The next group consisted of those in which strabismus was noted as a symptom of a systemic disease. Encephalitis and poliomyelitis were listed as the primary factor most frequently. One case in an adult involved thyroid imbalance.

4. In seven patients the strabismus was due to isolated paralyses.

5. The final division included five cases which were the result of injury. Although smallest in number, accounting for 7 per cent of the total, these were the most interesting with which to work. Two patients were little girls who had fallen from their bicycles and suffered concussions. Two cases resulted from automobile accidents, and one from a blow on the head.

Bryer[1] has emphasized in the 1958 *British Orthoptic Journal* the need for research in orthoptics. It has been noted by the author that the degree of intelligence varied in patients with different types of strabismus, particularly in those cases of intermittent exotropia of divergence excess. In the innervational group there had been noticed a lack in general central coordination. General intelligence and the power of concentration were found to be poor. Patients with acquired myopia or some other etiologic background were found, on the other hand, to respond quicker and to be more intelligent generally. It was suggested that an investigation of the relationship between refractive errors and intelligence should be carried out. Information on this point could lead to better treatment and consequent brighter prognosis.

There is also need for research on the etiology of squints. In order to accomplish this, we need the help and cooperation of the children and their parents. We should remember the importance of a detailed and accurate history.

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THE MANAGEMENT OF HETEROTROPIA IN THE YOUNG CHILD

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THIS paper presents (1) reasons for the early correction of heterotropia in the young child; (2) some methods used in their diagnosis and treatment; (3) common diagnoses, with illustrative case histories; and (4) a survey of results in 140 patients who received treatment prior to their fourth birthday.

The young child was selected without reference to the type of heterotropia present because there are two schools of thought regarding the advisability of early treatment, especially in regard to surgical correction. One school believes that surgical correction should not be undertaken before the child is five years old—when he is old enough for orthoptic treatment or has had a chance to outgrow the squint—or until such time as the deviation has become definite and unchangeable. Members of this school favor early and total occlusion, either monocular or alternating, until the child is five years old or longer, depending on when, and if, fusion can be taught. It is difficult to see the rationale for such treatment, for no one has been able to establish the existence of an anatomical center for fusion in the brain. One would expect such a center to start functioning once normal motor alignment of the visual axes is produced. Yet when these ideal conditions have been produced, insuperable diplopia has been the result.

We are indebted to Bernard Chavasse[1] for the explanation of the developmental nature of binocular vision. Briefly, this theory is that fusion is a result of learned and conditioned reflexes to produce binocular vision. For the development of normal fusion, it is essential that the motor, sensory and central components of binocular vision function correctly during a specific period, namely from birth to around five to six years of age. At this time the reflexes are said to become unconditioned and, therefore, fixed. If an obstacle lies in the pathway of any one of the components of binocular vision, normal development is interrupted. If this occurs at birth, or at an early stage during the development period of binocular vision, then abnormal reflexes are produced. If left uncorrected, they result in abnormal adaptation with usage, becoming in time as unconditionally fixed as the normal.

If we accept the theory that fusion is a learned reflex, then in the case of an early or birth onset of heterotropia, we cannot afford to wait until the child is five years old before attempting alignment of the eyes. If the heterotropia is left uncorrected, secondary abnormal sensory and motor correspondences will develop. If constant occlusion is employed to prevent such abnormal development, only the fixation reflexes are preserved. Fusion reflexes, either normal or abnormal, are denied development, since at no time are the eyes allowed to operate together, which is the prerequisite for fusion. Chavasse warned that the use

of an orthoptic department must first be diagnostic before it can pretend to be therapeutic. The treatment of squint consists of making various therapeutic measures fit the varied diagnostic picture. Immediate diagnosis and treatment is of vital importance. Chavasse stated that the surgeon must therefore be prepared to operate in the case of extremely small children and infants; and after the operation to employ other measures to binocular stimulation, not to elicit a correspondence which is not present, but reveal traces of it which are, or have been, there. Faced with these facts, delay of treatment means the end is directed towards a cosmetic rather than a functional result. The early institution of therapy is directed towards the functional result. This means ensuring good visual acuity and motor alignment, employing whatever means it takes to do this; occlusion, proper glasses and/or miotics, and/or surgical correction. Only in this way can nature be given a chance to produce normal binocular vision during the period when it is still undergoing development. It must be stated that not all patients receiving early treatment will enjoy good functional results, but at least they will have a cosmetic improvement at an early age rather than at a later one. Even with the expectancy of only a cosmetic improvement, the advantages of early surgical correction are considerable.

One of the advantages of early surgical intervention is that the very young child or infant does not fear hospitalization. These young patients do not usually experience the emotional upsets seen in older children. They complain less, and the physical healing process appears to be more rapid. The chances of developing incomitance, secondary sensory correspondences and inhibition of the fusion reflex are greatly lessened. A secondary consideration, and by no means a small one, is that in the early correction of heterotropia the child does not suffer the adverse psychological effects of being cross-eyed. It has been stated that the child is aware all through its childhood that it looks different from other children and is ashamed of it. Such disfigurement is also of great concern to the parents. The psychological trauma to the child and parents which results from crossed eyes, long-term occlusion, and prolonged orthoptics cannot be overlooked; whereas early correction of the squint gives the child a chance to make a normal adjustment, and makes the parents happy. If the factors in favor of early and immediate correction of heterotropia appear to have been overemphasized, it is in the hope that by reiteration of such facts, readers not convinced of their importance may reconsider the advantages of early and adequate therapy.

Some ophthalmologists may ask, "Of what benefit is the orthoptist to the child too young to be given exercises on the amblyoscope?" The answer to this question is that the average ophthalmologist, with the exception of the pediatric ophthalmologist, does not generally have the time, patience, perserverance, or surroundings to accomplish much in the preoperative diagnostic observation of the deviation or in the postoperative follow-up. The orthoptist is generally able to give the time and patience in the study of the deviation, and so is better equipped to handle the difficult or the problem child.

In describing some of the methods used to examine the young child, three broad chronological age groups are used. Allowance must be made

for the fact that cooperation from every child in any one age group will not be the same, and that there must be flexibility in methods of diagnosis with regard to mental age and temperament not commensurate with the chronological age.

Group A

Children Under 18 Months of Age

Care is taken to examine the child following his nap and feeding time, so that he is in a reasonable, pleasant humor. The mother holds the infant in her lap in an upright position. After casual observance, the examiner, prepared with an array of rattling toys, colored flashlights and baby talk, proceeds to get the child's attention. The gradual approach is the best one; sudden movements or noises are apt to scare the child. On the other hand, speed throughout the examination is essential because the child tires quickly. The objective of the examination is, first, to find out the direction and degree of the deviation and the type of visual fixation. A simple cover test, using a red flashlight held close to the examiner's nose as a fixation target, is in general easily executed. Should the child at first object to the examiner touching him, then the mother should be instructed to cover the eye until the child is accustomed to the procedure. This can be repeated at distance, with an assistant on hand to produce a blinking light along with a rattling toy at 20 feet or to call the child's name, if he can recognize it. If the fixation is observed to be good and central in either eye, then a prism measurement can be attempted. By using a picture hooked on to the examiner's glasses, and instructing the mother to focus a flashlight on it, the examiner has both hands free for the prism-and-cover test at near. The light is an essential aid to determine whether fixation is being maintained by observing the corneal light reflexes. The examiner should occasionally move his head to see whether the child's eyes follow, indicating that fixation is being maintained. If the prism-and-cover test cannot be executed, then estimation of the degree of deviation is made by the Krimsky or Hirschberg test. Next, by using a toy that holds the child's attention, the eyes may be rotated in the different fields of gaze. If the child looks and reaches out for the toy, it is given to him, and another toy is used to gain his attention once more in another of the fields of gaze. A considerable amount of patience may be necessary to observe the eyes in the upward and downward gaze; the mother may help in holding the child high on her shoulder to get the eyes in downward gaze. From this the orthoptist will have some idea of whether the movements are concomitant and whether there is any obvious A or V syndrome. Also, in watching the monocular rotations, she may observe whether there is any limitation of ocular movement. Next, the vergence reflex is checked with a flashlight by watching the corneal reflexes as the light is moved slowly in toward the nose, to see whether at any point the visual axes coincide. At this point the examiner notes whether binocular fixation is maintained in fusional convergence to the nose, one eye remains overconvergent, or one eye diverges. This gives a rough indication of the absence or presence of the fusional convergence reflex and is a factor to be considered in the estimation of amount of surgical correction necessary.

The findings from this examination are then correlated with the mother's account of the age of the child at onset, type of initial malfunction, and

the course of the deviation; and with the surgeon's findings on the refractive state of the eye. A tentative diagnosis can be made, to be followed up with further investigation and the course of treatment started.

The treatment may be *occlusion* if there is a definitely preferred eye, if fixation cannot be maintained, or if there is any doubt regarding the functioning of the abduction mechanism. The mother is instructed how to watch fixation before patching the eye each morning; if the fixation has changed before her next appointment, she discontinues the patching. In the event the fixation stays changed over a period of two days, she then patches the originally deviated eye. This is continued until fixation with either eye is possible. The mother is also asked to observe whether the nonoccluded eye can be fully abducted. If there is a high refractive error, *glasses* are prescribed. If there is but a small or moderate amount of hypermetropia, then isoflurophate (DFP) may be used as a diagnostic procedure. Thus, the child is observed over an approximate period of three months, during which time, on different visits, measurements are taken to record whether the deviation varies or is constant, and whether there is any increase or decrease in the heterotropia. Also to be determined is the total mechanical amount of the deviation; and whether any part of the deviation is accommodative in origin. Once it can be safely assumed that the deviation is nonvariable and mechanical in nature, the child is referred back to the surgeon for his advice and surgical alignment.

Group B
Children Between 18 Months and 2.5 Years of Age

The child in this age group is liable to be rather more apprehensive, having memories of visits to the pediatrician. Reassurance is essential. There are no such things as shots or eye drops, but merely toys to see and games to play. If the child is genuinely scared, then it is preferable to do little on his first visit but talk to the mother, allowing the child to become acclimated to his surroundings. Most of the children in this age group conduct themselves very well when seated alone. Others still need the security of their mother's lap. Either way, one expects to gain the following information on the first or second visit:

1. Presence or absence of gross amblyopia, by observance of the type of monocular fixation. In the case of the child over two years of age, this may be ascertained by a game. Patch one eye, and throw a dime along the floor away from the child, about a distance of 15 feet. Encourage the child to fetch the dime, and observe the effort needed to recover it. Repeat the game with the other eye occluded, and compare the results. Some children are able to recognize the pictures in the Costenbader accommodometer, or on Allen's preschool test.

2. Measurement of the deviation by the prism-and-cover test, providing central fixation can be maintained in both eyes. If not, then an approximation by the Krimsky or the Hirschberg test.

3. Measurements by prism and cover in the direct up-and-down gaze and, if attention span permits, in gaze to right and left.

4. Inspection of the binocular and monocular rotations of the eyes, recording any muscular anomalies.

5. Determination of the near point of convergence to a light and to an accommodative target.

6. Measurement of the deviation on the amblyoscope. Most children of this age like to see the pictures in the machine. Measurements are, of course, purely objective, but they help to confirm the accuracy of the prism-and-cover findings.

On succeeding visits one is able to determine whether the deviation is in part, or wholly, accommodative, or entirely mechanical. This is decided with the aid of the cycloplegic findings, checking the deviation against different lenses, and/or with isoflurophate, thus assessing the accommodative convergence relationship.

Group C

Children From 2.5 to 3 Years of Age

In this age group one is apt to meet with behavior problems. Once the child has been assured that there is nothing to fear, if he does not conform, either on account of temper, precocity, or lack of parental control, firm handling becomes essential. The examination has to be a matter of business and not of play. The mother's cooperation must first be obtained. If the child continues to misbehave in her presence, then she is asked to leave the room. In some cases it may take two or three visits before the orthoptist gains the child's confidence. Tact, sympathy, firm handling, and more than a little patience will bring results. On the first or second visits the following information is expected:

1. The assessment of visual acuity with the *E* game is possible in the majority of the three-year-olds. If the child is bright and the mother cooperative, she is able to teach the essentials of the *E* game at home.

2. Accurate prism-and-cover measurements at both 20 feet and 33 cm., using pictures for accommodative targets. These measurements should be recorded with and without correcting lenses.

3. Prism-and-cover measurements in the cardinal fields, if indicated and provided the child's attention can be maintained.

4. Ocular rotations, as in previous age group.

5. Near point convergence.

6. Near point of accommodation if the child is quick to recognize the *E* game.

7. Amblyoscope. Objective findings at first, though one may expect to get some subjective findings with later practice.

8. In some three-year-olds it is possible to perform diplopia tests with red and green glasses and to check for the blind spot syndrome.

Imagination can play an important part in holding the attention of the child in this age group. He cannot be expected to cooperate if he becomes bored or fatigued. Lights, when used for fixation targets, should have imaginary Captain Kangaroos, Mickey Mouses, or Peter Rabbits. The examiner must be alert and rapid in the examination. Rewards are helpful, such as a cookie and a star for good behavior and performance, and are incentives for a happy return visit.

As stated, the main objective in seeing children prior to three years of age is to compile an accurate diagnosis of the heterotropia and its course from the initial visit through observation visits over a period of three months. Equipped with this information the ophthalmologist is able to institute the necessary treatment.

A generalized outline of treatment related to specific and common diagnoses in heterotropia is now presented.

THE CONSTANT OR MECHANICAL TYPE OF ESOTROPIA OR EXOTROPIA

These deviations remain essentially unaltered by either occlusion, glasses or miotics. The deviation is invariable and, if allowed to continue, will result in the further development of sensory and, possibly, motor anomalies. These cases require early surgical alignment. The orthoptist can help in the post-operative follow-up by continued observation of any residual deviation. If there is an immediate residual esotropia, the use of isoflurophate is usually tried to promote a binocular fixation. The red filter is used if there is a preferred or constant monocular fixation. The small pupils and different colored images will stimulate the fusion reflex if there is potential fusion. A constant check is kept to see that suppression does not recur, as it may well do, in cases originally amblyopic. An example of this is seen in the case history of Lynn.

Lynn was first seen at the age of three years, with a history of a left esotropia since she was 18 months of age. The refractive error was negligible. There was a gross amblyopia in the left eye; she was unable to see beads at a distance of one meter. There was a constant and concomitant esotropia of 40 prism diopters. Occlusion of the right eye was carried out until fixation could be maintained in the left eye. This was followed closely by surgical correction—bilateral medial rectus recessions of 3 mm. in each eye. Ten days following the operation there was a residual left esotropia of 12 prism diopters at distance fixation, and 14 prism diopters at near fixation. Isoflurophate was given, and the red filter on the right eye was prescribed. The esotropia decreased, but the vision in the left eye was only 20/100 as recorded by the *E* game. Total occlusion of the right eye was used on alternate days, with the red filter on the right eye on the other days. One year later (the child now age four years): Vision O.D., 20/30; vision O.S., 20/30; prism-and-cover test, orthophoria at 20 feet and esophoria of 4 prism diopters at near; near point of convergence, 4 cm. with a good vergence reflex. The troposcope showed simultaneous macular perception at zero, peripheral fusion 0, diverged 8 diopters, converged 50 diopters. Stereopsis reported to the fly card.

For those cases in which the initial surgical procedure has corrected only 50 per cent, or less, of the deviation and a second operation is planned, occlusion (complete or partial) may be continued until this is done. For the residual exotropias, the mother is taught simple near point convergence exercises using small colored pictures on a tongue depressor, or a penny is held close to the nose, both eyes maintaining foveal fixation while the child guesses "heads" or "tails." Or two pictures on tongue depressors may be held in a line in front of the nose, one at 10 cm., the other at 30 cm. The child has to look from one to the other, making a jump convergence movement.

CASE HISTORY

History and Examination:
David, aged 2 years and one month. One month ago mother noted the right eye was turned in. Intermittent onset; no recent illness, or trauma. No known hereditary factor. No history of birth injury.

Cycloplegic refraction: +0.25 O.U.
DFP had been used for two weeks prior to first orthoptic visit.

Cover test:
Intermittent right esotropia distance and near

Prism cover test (△):
E — ET 14; E — ET' 8

Near point of convergence: 4 cm.

Field measurments (△):

Right	Sl. E'
Up	0
Left	ET' 12
Down	Sl. E'

Versions:
Question weakness lateral recti, particularly left, with overshoot right medial rectus

Major amblyoscope:
Objective angle +32△

Diagnosis:
Intermittent right esotropia, possibly accommodative.
Suggested continuing on DFP and observing.
Three weeks later there was a constant right esotropia, with ability to alternate.

Prism cover test (△):
ET 30; ET′ 16/25
Field measurments (△):

Right	ET′ 16
Up	ET′ 16
Left	ET′ 16
Down	ET′ 16

The deviation was observed over a period of six months, the distance deviation varied between 25 to 40 prism diopters at distance. DFP no longer gave any help.

Preoperative Examination:
VOD = 20/30; VOS = 20/30
Prism cover test (△):
ET = 45 (Alternates)
ET′ = 45
Field measurements (△):

Right	ET′ 45
Up	ET′ 45
Left	ET′ 45
Down	ET′ 45/50

Near point of convergence:
Unlimited but overconverges to nose
Versions: Appear concomitant
Major amblyoscope:
Objective angle +50△
Surgery:
Bimedial recession of the medial recti 3 mm. O.U.
Two Weeks Later:
VOD = 20/30; VOS = 20/30
Prism cover test:
Orthophoria
E (T)′ = 6△
Near point of convergence: 5 cm.
Major amblyoscope:
Simultaneous macular perception at 0. Peripheral fusion with small aplitudes and some suppression right eye.
Was given red filter work only.
Three Months Postoperative:
VOD = 20/20; VOS = 20/20
Prism cover test (△):
E = 2 on 20/30
E′ = 6
Versions: Full
Near point of convergence: 3 cm.
Major amblyoscope:
Simultaneous macular perception +8/10△. Not sufficient attention to measure fusion amplitudes.
Near Wirt stereopsis vision: 60 per cent

THE PURELY ACCOMMODATIVE TYPE OF ESOTROPIA

The objective is to find the minimal lens correction that produces binocular fixation at distance and near and, whenever possible, the visual acuity. When the lenses are prescribed, it is essential to determine the presence or absence of amblyopia. If amblyopia is present, then occlusion shoud be instituted at the same time as, or prior to, wearing glasses. The mother is instructed how to check whether the child's eyes are straight when wearing his glasses, and an effort is made to impress her with the importance of seeing that the child wears his glasses at all times. Once it has been ascertained that there is equal vision and binocular single vision in glasses, the child is then checked every six months. The purpose is to see that binocular single vision is being maintained, and to determine whether any decrease in the lenses can be tolerated. Between the ages of five to seven years, depending on the maturity of the child, dissociation exercises are given to teach binocular single vision without glasses, whenever possible.

CASE HISTORY

History:

Robert, aged 3 years. Left eye noted to turn in around age one year. Previous treatment. Glasses from physician in Frankfurt, Germany, at age 2. Slight turn in glasses noted by parents. Hereditary factor is not known, since he is an adopted child.

Glasses:
Full cycloplegic (Cyclogyl) findings:
O.D. +5.00 +1.00 cyl x 180
O.S. +4.50 +1.50 cyl x 125
First visit: August 4, 1958
Cover test:
Slight left esotropia distance, increases at near with correction
Marked left esotropia without correction
Prism cover test (△):
ET = 4 fixating a light cc
ET′ = 16 on 20/30 cc
ET = 40 sc
ET′ = 50 sc
Near point of convergence: Unlimited
Versions: Grossly normal
Field measurements (△):

Right	ET′ 40
Up	ET′ 40
Left	ET′ 40
Down	ET′ 40

No subjective response on E or troposcope

Diagnosis:
Left esotropia with small abnormal A/C ratio. Accommodative

Treatment:
DFP prescribed for one month, with tapering out period of two months. Red filter occlusion on O.D. (Vision O.S. found to be 20/50 on second visit.)

Final visit: April 9, 1959
VOD cc = 20/20 with E
VOS cc = 20/20 with E

Prism cover test (△):
E cc = 2
E′ cc = 12
ET sc = 45
ET′ sc = 45

Near point of convergence: 3 cm.

Major Amblyoscope:
Angle +8△ no hyper with correction. Simultaneous macular perception. Peripheral fusion +8△, diverged to −5△. Converged to +20△.

Remarks:
Observation advised to see that binocular single vision is maintained with correcting lenses. Possible dissociation exercises later. Patient moved to Texas.

THE MIXED TYPE OF ESOTROPIA

This type of esotropia has both an accommodative and a nonaccommodative component. The accommodative part of the deviation is first assessed by the use of miotics, and if it is a large factor in the deviation, it is corrected with lenses. Any amblyopia is treated with occlusion from the start, either total or partial occlusion with the red filter on the dominant eye. In correcting any accommodative deviation, great emphasis is laid on the importance of starting occlusion before or at the same time as the accommodative element is corrected. Should the occlusion be delayed, a new set of secondary sensory correspondences with the change in the degree of deviation is to be expected. With the accommodative part of the deviation corrected and the sensory correspondences as normal as can be expected, surgical correction of the mechanical part of the deviation is essential. Immediate postoperative examination is essential to ensure that the correcting lenses are the right strength to induce binocular vision, and that partial occlusion, if necessary, is carried out. The strength of the lenses may have to be decreased if any divergence of the visual axes becomes apparent, and increased, if possible, by stronger correction or augmented by isoflurophate if residual esotropia persists. A bifocal add is used if an abnormal accommodation-convergence relationship at near persists. Simple exercises are employed to stimulate binocular vision. For example, take two pictures on tongue depressors. Hold one about 33 cm. from the eyes of the child in a direct line with his nose, and another about a meter away. Call the child's attention to the picture a meter away, then to the one up close, and observe the type of fixation he makes. Should the child overconverge to either distance, tell him to look at some object 20 feet away, then to "look easy" back to the picture. Should he still overconverge, move the picture in to a point where he can get binocular fixation, and move the picture slowly backward and forward in an effort to stimulate a normal fusional convergence movement. If preferred, red and white flashlights may be used. This produces less incentive to accommodative effort when the convergence factor is excessive. If there is poor convergence effort, then the pictures stimulating accommodation are preferred.

CASE HISTORY

History:

Barry, aged 3 years, 9 months. O.D. crossed from birth. Has become more marked. No history of birth trauma. No known hereditary factors. Previous treatment: glasses at age 2 years.

First and second visits: January 1957
Glasses (Full cycloplegic)
O.D. +5.00; O.S. +4.50
VOD cc = 20/40; VOS cc = 20/40

Cover test:
Left esotropia and hypotropia distance and near with correction
Prism cover test (△):

ET cc = 14 c RHT 30 ++	Fixing O.S.
ET cc = 14 c LHT 5	Fixing O.D.
ET′ cc = 20 c RHT 30 ++	Fixing O.S.
ET′ cc = 25 c LHT 5	Fixing O.D.
ET sc = 35 c DHT	
ET′ sc = 35 c DHT′	

Versions:
Upshoot both inferior obliques, right more than left. Query paretic left superior rectus. Bilateral weakness superior obliques, right more than left.

Field measurements:

Right	DHT′
Right and Up	DHT′
Up	RHT′ 30; ET′ 16
Left and Up	RHT′ greatest
Left	RHT′ ++
Left and Down	RHT′ ++
Down	ET′ 30; RHT′ 16
Right and Down	RHT′ least

One Month Later:
Surgery — 10 mm. recession R.I.O.
Three Months Later: Using DFP and glasses
Prism cover test (△):

E cc = 25 c LH 5	fixing O.D. on 20/30
E cc = 16 c RH 16	fixing O.S. on 20/30
E′ cc = 18 c LH	fixing O.D. on 20/30
E′ cc = 18 c RH	fixing O.S. on 20/30

Near point of convergence: 4 cm.
Comment:
Appears to be maintaining binocular single vision distance and near with lenses.
One Month Later:
Glasses increased to
O.D. +5.50 +1.00 x 90 = 20/30
O.S. +5.00 = 20/30
One Year Later:
Once again showing a manifest hypertropia and esotropia, and second surgery advised.
Prism cover test (△):
ET cc = 15 c RHT 12 fixing O.S.
ET′ cc = 25 c RHT′ 20 fixing O.S.
August 1958 — Recession medial recti O.U. 2 mm. Tucked right superior oblique.
Eleven Months Later:
July 1959, aged 6 years.
VOD cc = 20/20; VOS cc = 20/20
Prism cover test (△):

E cc = 10 c LH 6	fixing O.D.
E cc = 14 c RH 18	fixing O.S.
E′ cc = 18 c LH 8	fixing O.D.
E′ cc = 18 c RH 18	fixing O.S.

Controlled without glasses. Without correction eyes straight by relaxing accommodation. Binocular visual acuity less than 20/200. Marked alternating esotropia and hypertropia on accommodation without correction.
Versions:
Weak left superior rectus, upshoot left inferior oblique. Only very slight upshoot right inferior oblique on levo-elevation.
Major amblyoscope:
Simultaneous macular perception orthophoria "controlled" with correction. Peripheral fusion 0, diverged to −5△, converged to +30△. Claims stereopsis vision to fly and 30 per cent near Wirt stereopsis vision.
Near point of convergence: 5 cm.
Comment:
Mother claims that eyes are straight with glasses. Dissociation exercises not contemplated at this time in view of high hyperopia and dissociated hyperphoria.

THE CYCLIC TYPE OF ESOTROPIA

The cyclic type of esotropia refers to those squints showing a marked esotropia one day and straight eyes the next, with often little or no esophoria. The etiology is somewhat obscure. Measurements are recorded during both phases. The mother is instructed to keep a daily record noting the frequency of the deviation. In not a few cases, the deviation becomes progressively more frequent; should it become permanent or present at least 75 per cent of the time, surgical correction is usually the treatment of choice. Postoperative care should be the same as that recommended for the mechanical type of esotropias. Although these cases are not too common, they are usually observed in the younger age group.

CASE HISTORY

History and examination:
Sharon, aged 2 years. Sudden onset of alternating esotropia following sore throat and fever of 104 degrees six months ago. Saw ophthalmologist, who prescribed use of DFP, which helped at first but later esotropia returned every other day. Eyes were said to be straight one day, crossed the next.
Cycloplegic refraction:
+1.00 O.U. No glasses
First Examination:
Prism cover test (△):
ET = 12 alternates; E(T)′ = 8

Versions: Appear concomitant
Near point of convergence:
Unlimited, good vergence reflex
Major amblyoscope:
Objective angle +12. Appears to have fusional convergence judged objectively.

Examination One Month Later:
Prism cover test (△):
ET = 40; ET′ = 40
Versions:
Full rotations. No A or V syndrome
Field measurements (△):
Up ET′ 35
Down ET′ 35
Parents state that esotropia is becoming more frequent. Observed for two months; during last month, eye crossed every day.

Surgery:
Bilateral recession medial recti 3 mm.
Immediate postoperative result:
Orthophoria distance and near

Six Months Later:
No deviation noted since operation
VOD = 20/30; VOS = 20/30
Prism cover test:
Orthophoria distance and near
Versions: Full
Near point of convergence: 3 cm.
Stereopsis vision to fly
Major amblyoscope:
Simultaneous macular perception orthophoric. Peripheral fusion 0; diverged to −6△; converged to +30△.

THE INNERVATIONAL OR VARIABLE TYPE OF ESOTROPIA

Those deviations without any marked accommodative factor or specific cycle of deviation usually are classed as innervational. They show marked variability in degree and periodicity. They are often seen in conjunction with nystagmus and/or a dissociated vertical deviation. As in the cases of the cyclic deviations, it is important to observe and follow the course of the deviation over a period of three to six months, or longer, in order to determine the degree and variation of the deviation and its relation to the general physical and emotional state of the child.

In many cases the deviation may be controlled by the use of isoflurophate. Such therapy, if effective, is preferred to surgical correction, for often this type of deviation lessens with age. On the other hand, if the deviation becomes progressively worse and no longer responds to miotics, surgical intervention is usually justified even though the results are far from predictable. The operation is usually planned to correct the horizontal component alone unless there is an obvious vertical deviation not of the dissociated type. These cases are perhaps the hardest to manage, and it is difficult to effect a good result. In general there is no dramatic or quick cure, and a conservative approach requiring long-term observation is usually involved before anything as drastic as surgical correction may be considered.

CASE HISTORY

History:

Dennis, age 3. Left eye has turned in since birth. Eye straight on waking, turns in markedly when child is tired or ill. Deviation has remained about the same. Birth history: forceps delivery, badly marked in right frontal area. No known hereditary factor. No previous eye treatment. Hyperexcitable child (Dennis the Menace).

First visit: January 15, 1957
Cycloplegic refraction:
+1.00 O.U. No glasses
Vision:
Retrieves dime thrown at 20 feet, with either eye occluded
Cover test:
Variable left esotropia noted distance and near
Prism cover test (△):
ET = 15 . . .40; ET′ = 40
Versions:
Questionable left inferior oblique overaction
Field measurements (△):
Up ET′ 40 ++
Down ET′ 18/20
Near point of convergence:
Unlimited, but never binocular. Left eye overconvergent to nose.
Major amblyoscope:
Angle of deviation:
+35/40 c LHT 8 fixing O.D.
+40 No hyper fixing O.S.

Diagnosis:
Congenital variable left esotropia, with latent nystagmus in left eye; possible A syndrome.

Treatment:
Total occlusion of right eye was given to try and promote fixation with left eye. This was achieved within a few weeks, and vision with E was 20/30 either eye. On taking the patch off, eyes were straight for a short while. DFP therapy was started, which did not give an immediate good effect, but after using it for two months, the deviation had become almost entirely a controlled, though marked, esophoria. DFP was gradually decreased, and was used only on the days when the eye was seen to cross.

Last visit: June 13, 1958
VOD = 20/40
VOS = 20/40
VOU = 20/30

Prism cover test (△):
E = 4 on 20/30
E′ = 14 on 20/30

Near point of convergence:
Unlimited, and binocular, good vergence reflex

Major amblyoscope:
Simultaneous macular perception 0/−4△. Peripheral fusion 0△; diverged −20?△; converged +30△.

Mother reports she has to use DFP on an average of once a week, and that the eye crosses only on very rare occasions.

THE INTERMITTENT EXOTROPIAS

Orthoptics *per se* has perhaps the most to offer in the treatment of heterotropia. As a general guide, the exotropia not evident more than 50 per cent of the time may be left on observation until the child is old enough to get the most from orthoptic treatment; that is, provided the divergence is not of a degree warranting surgical correction. Orthoptic treatment can usually be started when the child is four and a half years old, later if the cooperation is poor. However if the deviation is large—30 prism diopters or over—and is noted by the parents at least 70 per cent of the time, then early surgical correction is favored. This will prevent the conditioning to suppression, which has to take place each time the eye diverges. Over the years the suppression may become so well grounded as to make its eradication by orthoptic means an arduous, sometimes an impossible, task. In the majority of cases, it is not possible to teach an objective appreciation of diplopia and voluntary control of the divergence to the child under four and a half years old. In consequence the only means left to stimulate a binocular fixation lie in simple convergence exercises already described, or in the red filter worn over the dominant eye. In the diagnostic work-up and following observation visits of the very young child with intermittent exotropia, the important facts to be determined are the greatest amount of divergence, the presence or absence of the A or V phenomenon, the existence or nonexistence of spontaneous recovery to binocular fixation at 20 feet. With this information, it can be determined whether surgical intervention is necessary immediately or whether it can be deferred until the child is old enough to cooperate with intensive orthoptic therapy.

CASE HISTORY

History:
Forsythia, aged 2.5 years. Intermittent left divergence noted from age eighteen months. No known hereditary factor. No known birth injury. No previous eye treatment.

First visit: May 8, 1957

Cover test:
Marked alternating divergence for distance, preference for left eye. Marked latent divergence at near

Prism cover test (△):
XT = 45; X′ = 30

Field measurements (△):
Up X(T)′ 30 (approximate)
Down X′ 18

Near point of convergence: 5 cms.

Versions:
Appear normal

Major amblyoscope:
Angle of deviation—40△ fixing either eye.
Unable to ascertain retinal correspondence

Diagnosis:
Intermittent exotropia with questionable V syndrome.

Recommendations:
Observation until measurements are consistent, then surgical correction because of degree of deviation.
Presurgery measurements: August 20, 1957
Prism cover test (△):
XT = 40; X′ = 14
Field measurements (△):

Up	X(T)′ 16
Down	X′ 12

Surgery:
August 27, 1957—Bilateral recessions of the lateral recti 4.5 mm.
Last visit: June 10, 1958
VOD = 20/40; VOS = 20/40
NVOD = 20/20; NVOS = 20/20
Prism cover test:
Orthophoria
X′ 2
Field measurements (△):

Right	E′ 8
Up	Orthophoria
Left	Orthophoria
Down	Orthophoria

Near point of convergence: 3 cm.
Major amblyoscope:
Simultaneous foveal perception +5△. Peripheral fusion +5△; diverged −5△; converged +20△.

CONGENITAL PARALYTIC SQUINTS AND OCULAR TORTICOLLIS

Congenital paralytic squints and ocular torticollis are primarily surgical problems. The orthoptist should secure an accurate diagnosis of the muscles involved and measurements of the deviations, from which the surgeon may plan his surgical correction.

CASE HISTORY

History:
C. R., aged 3.5 years. Marked head tilt to left since a baby. Birth history: Protracted labor, 15 hours; no instruments. No known hereditary factor.
First visit: June 3, 1957
Cycloplegic refraction:
+1.50 −0.50 x 180 O.U. No glasses given
VOD = 20/20; VOS = 20/20
Cover test:
Left hypotropia distance and near
Prism cover test (△):
RHT = 40 fixing O.S.
RHT = 15 fixing O.D.
RHT′ = 45 fixing O.S.
RHT′ = 23 fixing O.D.
Field measurements (△):

Right	RHT′ 25
Right and Up	RHT′ 25
Up	RHT′ 25/30
Left and Up	RHT′ 35
Left	RHT′ 40
Left and Down	RHT′ 40
Down	RHT′ 35
Right and Down	RHT′ 30

Surgery:
June 20, 1957—10 mm. recession right inferior oblique
Five months later:
Prism cover test (△):
RHT = 35 fixing O.S. distance and near
Sl. XT c RHT 16 fixing O.D. distance and near
Versions:
Relative weakness left inferior oblique, overaction right superior rectus. Some upshoot right inferior oblique. Weak right superior oblique. Overaction left inferior rectus. Weak right inferior rectus. Overaction left superior oblique.
Field measurements (△):

Right	RHT′ 18
Right and Up	RHT′ 18
Up	RHT′ 14
Left and Up	XT′; RHT′ 14
Left	RHT′ 20+
Left and Down	RHT′ 40+
Down	XT′; RHT′ 35
Right and Down	RHT′ 30

Surgery:
January 9, 1958—Tucked right superior oblique
Three months later:
Prism cover test (△):
RHT 14 fixing O.D. distance and near
RHT′ 30 fixing O.S. distance and near
Field measurements (△):

Right	RHT′ 30
Right and Up	RHT′ 18
Up	RHT′ 5
Left and Up	Sl. DHT′
Left	RHT′ 14
Left and Down	XT′; RHT′ 30
Down	Sl. XT′; RHT′ 30
Right and Down	RHT′ 30

Surgery:
May 15, 1958—Tenotomy left superior oblique
Eight months later:
Prism cover test (△):

Sl. E(T)	fixing O.D.
RH(T) = 14—16	fixing O.S.
E(T)′ = 6-8	fixing O.D.
E(T)′ = 6-8 c RH(T)′	12 fixing O.S.

VOD = 20/20; VOS = 20/20

Field measurements (△):

Right	ET′ 8; Sl. DH
Up	ET′ 6; LHT′ 5
Left	ET′ 6; RHT′ 6
Down	ET′ 14; RHT′ 10

Near point of convergence: 7 cm.

Major amblyoscope:

Simultaneous macular perception +5/10△ (RH controlled). Attempts peripheral fusion, amplitudes unstable due to tendency to become right hypertropia.

THE A AND V SYNDROMES

The A and V phenomena, only recently recognized, exist in many cases of esotropia and exotropia. These phenomena have undoubtedly been contributing factors to the often puzzling surgical overcorrection obtained in the past. Adequate diagnosis with measurements in the cardinal fields of gaze is essential before surgical correction of either the syndrome or the horizontal deviation can be successfully planned. An operation to eliminate the syndrome in a young child can be deferred in those cases in which binocular fixation can be achieved and maintained in the primary positions, since it is technically easier to evaluate and surgically correct vertical deviations in an older child.

CASE HISTORY

History:

J. T. First seen aged 2.75 years, with a history of the right eye being crossed from birth. Normal birth history. No known hereditary factor.

Cycloplegic refraction: +1.50 O.U.

Head posture:

Chin depressed, eyes elevated

Prism cover test (△):

ET = 25
ET′ = 50+ (RHT fixing O.S.)
+4.00 Add = no difference

Versions:

Marked overaction of both inferior obliques on lateroversions and elevation. Relative insufficiency of the superior recti and superior obliques of both eyes.

Field measurements (△):

Right	ET′ 50; LHT′
Right and Up	ET′; Marked LHT′
Up	ET′ 18
Left and Up	ET′ ++; Marked RHT′
Left	ET′ 50; LHT′
Left and Down	ET′ +; RHT′
Down	ET′ 80 +
Right and Down	ET′ ++; LHT′

Major amblyoscope:

Angle: +40 c LHT 10 fixing O.D.
+50 c RHT 10 fixing O.S.

A trial of DFP was decided, to see whether the convergence would decrease.

Three weeks later:

Prism cover test (△):

E(T) = 14; E(T)′ = 12

Field measurements (△):

Up	Fusion slight E′
Down	Marked ET′

Versions: As before

Major amblyoscope:

Angle: +25 c LHT 10 fixing O.D.
+25 c RHT 10 fixing O.S.

DFP was continued, and one month later the patient had a full-time esophoria in the primary positions of gaze, 6 diopters for distance and 12 for near. These findings were maintained for one year with the help of DFP in minimal doses. However, at the end of one year it was still necessary to use DFP every third night to prevent a frank esotropia. Surgical correction was then recommended.

Surgery:

Recession each inferior oblique 8 to 10 mm.
Resection lateral recti both eyes 8 mm.

Three weeks postoperative:

VOD = 20/30; VOS = 20/30

Prism cover test (△):

E(T) = 10 c Sl. RH
E(T)′ = 16 c RH(T)′

Field measurements (△):

Up	E(T)′ 8
Down	ET′ 35

Near point of convergence: 4 cm.

Versions:

Slight upshoot right inferior oblique.

One month later the near esotropia increased to as much as thirty diopters, and DFP was again tried, but unfortunately the child developed an allergy to it, so bifocals were given, without an effect. Second operation was then planned.

Preoperative measurements:

Prism cover test (△):

E(T) = 8
ET′ = 35 c Sl. DHT′
ET′ = 30 with segment

Field measurements (△):
Right ET′ 35; LHT′
Up ET′ 16
Left ET′ 35; RHT′
Down ET′ 35; LHT′
Near point of convergence: 3 cm.
Fair vergence reflex.
Versions:
Marked weakness of superior obliques, slight upshoot of both inferior obliques.
Surgery:
Recession of medial recti 2.5 mm. and lowered 3 mm. O.U.
One month postoperative:
Using DFP, no allergy
VOD = 20/30; VOS = 20/30
Prism cover test:
E(T) = 12; E(T)′ = 10
Muscle action:
Right LHT′
Up 0
Left Sl. ET′; RHT′ 8
Down ET′ 18; DHT′
Near point of convergence: 3 cm.
Good vergence reflex.
Versions:
Slight upshoot inferior obliques both eyes, slight weakness superior obliques.
Major amblyoscope:
Simultaneous macular perception +5△ with LHT 4, questionable peripheral fusion.
Four months postoperative:
VOD = 20/30; VOS = 20/30
Prism cover test (△):
X = 6; X′ = 8
Field measurements (△):
Right X′ 8; LH(T)′
Up X′ 4
Left X′ 8; RH(T)′
Down X′ 6; DH
Near point of convergence: 5 cm.
Absolute prism convergence at 20 feet = 30△.
Versions:
Very slight upshooting inferior obliques.

A SURVEY

The significant findings in a series of patients (under 4 years of age) who received treatment for heterotropia were studied. Case histories were taken without selection, either regarding diagnosis or result, from the files of Orthoptic Service over a period of four years. The patients were referred by a group of doctors in Atlanta and the State of Georgia. Not included in the series are those patients referred prior to four years of age who are currently undergoing diagnosis, are receiving treatment, are awaiting surgical correction, or have undergone an operation too recently for results to be evaluated.

There was a total of 140 patients whose treatment had progressed far enough to be included in the survey. Not all of these patients have been discharged. When the patient is so young that it is not possible to safely assume the complete stabilization of his binocular mechanism, observation checks are made every three to six months. Other patients, particularly those with accommodative problems, are awaiting an age when they will be able to learn dissociation of accommodation from convergence in order to dispense with wearing glasses; the cases of those not wearing glasses are being controlled by the intermittent use of isoflurophate.

The results of therapy were functional in 97 of the 140 cases (69 per cent). In 43 cases (31 per cent) only a cosmetic improvement was noted (table I).

The functional results were achieved by surgical correction and orthoptic treatment in 68 cases. In 29 cases (all in the age group from 2.5 to 4 years) results were achieved by orthoptics alone. The average number of visits per patient was fourteen.

A breakdown was made according to age. Group A consisted of 14 patients first seen before they were 18 months old. Group B, children between the ages of 18 months and 2.5 years at the time of their first visit, contained 20 cases. Group C was the largest group—106 children first seen after they were 2.5 years old but before they had reached the age of 4 years. An analysis of the results of

TABLE I
DIAGNOSTIC ANALYSIS OF 140 CASES OF HETEROTROPIA

TYPE OF DEVIATION	TOTAL	FUNCTIONAL			COSMETIC		
		(1)	(2)	(3)	(4)	(5)	(6)
Nonaccommodative or Mechanical Esotropia	36	7	3	12	10	4	—
Mechanical Esotropia with Isolated Vertical	6	1	—	1	1	2	1
Fully Accommodative Esotropia	12	7	—	5	—	—	—
Accommodative Esotropia with Abnormal A/C ratio	4	2	—	2	—	—	—
Mixed Esotropia (Accommodative/nonaccommodative with or without abnormal A/C ratio)	36	7	—	21	2	6	—
Intermittent Esotropia	1	—	—	1	—	—	—
Intermittent Exotropia	6	4	1	1	—	—	—
Constant Exotropia	1	—	—	1	—	—	—
Cyclic Esotropia	1	1	—	—	—	—	—
Innervational/Variable Esotropia	8	—	1	4	1	1	1
Ocular Torticollis	2	—	—	2	—	—	—
Esotropia with the A Syndrome	9	1	1	2	—	5	—
Esotropia with the V Syndrome	12	—	—	4	2	6	—
Exotropia with the A Syndrome	3	1	1	1	—	—	—
Exotropia with the V Syndrome	3	1	—	1	—	1	—
Total	140	32	7	58	16	25	2

therapy in the various age groups is given in Table II.

Heredity was an etiologic factor in 64 per cent of the cases in Group A, in 45 per cent in Group B, and in 55 per cent in Group C. The age of the child at time of onset of the squint also bore some relation to the results of therapy (table III).

In the classification of the results given in the tables, an explanation is necessary. The functional results have been graded into three groups signified by numbers (1), (2), (3).

(1) Binocular single vision in all fields of gaze, as determined by the cover test while the patient regards a 20/30 symbol at both distance and near fixation, and in all the fields of gaze. Fu-

sion demonstrable on the amblyoscope, and/or on prism vergence. Stereoscopic vision reported either to the Fly and/or Near Wirt cards.

(2) Binocular single vision in the primary positions of gaze, showing complete recovery on the cover test to 20/30 vision at distance and near fixation, but absence of binocularity in one or more of the cardinal fields of gaze. Fusion with amplitudes measured on the amblyoscope or prism vergences and stereoscopic vision reported to the Fly or Near Wirt cards.

(3) Gross binocular vision.* This large group includes the following subtypes:

(a) Those cases showing an incomplete binocular recovery to bifoveal fixation. Inasmuch as the term *fixation disparity* has fallen into disrepute on account of its application to different clinical findings, the descriptive name is used—*incomplete recovery to bifoveal fixation.* On making the cover-uncover test, while the patient is fixating a 20/30 symbol, first at distance then at near, the uncovered eye is first regarded by the examiner to see whether there is any movement to assume fixation at the same time as the cover is placed over the opposite eye. When a slight movement to secure central fixation is made, this is either recorded as a small angle tropia, a shift, or a fixation disparity. The degree of this movement may be measured in diopters by placing the correcting prism to eliminate this movement over the shifting eye, at the same time that a cover is placed over the opposite eye. Next the alternate-cover test is made. The patient again fixates the 20/30 symbol. While the cover is being moved from the right to the left eye, a dioptric prism measurement is made of the total deviation thus manifested. For example: Prism cover test (at 20 feet) shows by the cover-uncover test, an esotropia of 2 prism diopters in the left eye. By the alternate-cover test, an esophoria of 10 prism diopters. It has been found on routine clinical testing that these patients display binocular responses to prism vergences, show fusion with amplitudes as measured on the amblyoscope, and report stereopsis to the Fly and even the Near Wirt cards in many cases.

(b) Those cases in which binocular single vision for near is achieved only by means of a bifocal add.

(c) Those cases in which dissociated vertical deviation occurs even when there is a complete recovery to binocu-

TABLE II
GROUP ANALYSIS OF RESULTS IN 140 CASES OF HETEROTROPIA

GROUP	NO. OF CASES	AV. AGE LAST SEEN (YRS.)	FUNCTIONAL			COSMETIC			AV. DURATION OF SQUINT BEFORE TREATMENT (MONTHS)	
			(1)	(2)	(3)	(4)	(5)	(6)	FUNCTIONAL	COSMETIC
A	14	3.3	—	1	8	3	1	1	9.9	10.2
B	20	3.8	5	—	7	4	4	—	12.7	19.9
C	106	5.1	27	6	43	9	20	1	16.0	18.0

*Some of the cases included in Functional (3) could well be (1) but immaturity prevented adequate testing.

TABLE III
NUMBER OF CHILDREN IN WHOM ONSET OF SQUINT OCCURRED BEFORE AGE SIX MONTHS IN RELATION TO RESULTS OF THERAPY

GROUP	NO. OF PATIENTS	FUNCTIONAL			COSMETIC		
		(1)	(2)	(3)	(4)	(5)	(6)
A	11	—	1	6	—	4	—
B	13	3	—	4	—	6	—
C	37	4	4	17	—	12	—
Total	61	39			22		

lar fixation on the cover test in the primary positions of gaze, and in some cases in all the fields of gaze. These patients may demonstrate stereopsis to the Fly card, and maintain some prism vergences, yet be unable to achieve fusion on the amblyoscope when the dissociated hyperphoria becomes a hypertropia.

The cosmetic results have been graded (4), (5), (6).

(4) Excellent. Indicating that the deviation is 10 prism diopters or less in all the fields of gaze, for both near and distance fixation.

(5) Good. Those cases where the deviation ranges between 10 and 20 prism diopters in all the fields of gaze.

(6) Others. Appearance only fair. Particular mention is made of the category (6), since at this date it is not known how to improve the condition of these patients. There are two such cases which must be considered as failures. A brief report follows:

(a) Gen Ellen. First seen aged 3 years and 9 months, with a history of the left eye turning in from birth. The strabismus was variable in degree. The father had a squint as a child and is said to have outgrown it.

Diagnosis of a variable or "innervation" esotropia with a dissociated hypertropia and a left amblyopia of 20/100 was made. Occlusion of the right eye, followed by DFP therapy, was prescribed. The child is now six years old, and the vision is 20/30 in both eyes. There is a marked esotropia and dissociated hypertropia at times, and fair control at others. Control is said to vary with emotional states and with an asthmatic condition. There is a definite overaction of both inferior obliques recorded on field measurements, with a resulting A syndrome. The latter finding is converse to the normal expectation and therefore makes any surgical decision a difficult one.

(b) Ronald. First seen at age one year, with a history from birth of the left eye crossing. There is no history of birth trauma and no known hereditary factor. The right eye had been occluded for one month prior to orthoptic evaluation.

On examination a variable right esotropia was found with a right hypertropia of, at that time, undetermined origin. The left eye was occluded until fixation was good in either eye, and DFP was used for diagnostic purposes. DFP failed to influence the esotropia, which became a constant deviation of 50 prism diopters both at distance and near fixation. There was a marked upshoot of the right inferior oblique. A bilateral recession of the medial recti, 4 mm. on each, was done when the child reached the age of 13 months. The child is now three years old. Prism cover test at 20 feet shows an esotropia of 16 to 18 diopters with a left hypertropia of 16 diopters. Near prism measurement shows an esotropia of 25 diopters and a left hypertropia of 16 diopters. On versions there is a weak left superior oblique, an overaction of the right superior oblique, and a moderate upshoot of both inferior obliques. The esotropia on looking up is 18 diopters with a left hypertropia of 6; on looking

down there is an esotropia of 8 diopters with a left hypertropia of 16. Further surgical intervention at this time is not contemplated, since on casual gaze the right eye at times diverges. The eyes appear to be straight most of the time, though the measurements do not indicate this, and the occasional divergence of the right eye is not accountable.

The final evaluation of results in this series cannot be accurately made at this time because the children in the group are still too young. The average age of the 140 patients at the time of last examination was 4.6 years. These results should be reviewed five or ten years hence. The survey was undertaken merely to show that it is possible in working with small children to achieve either complete binocularity or improved appearance.

SUMMARY

The advantages of early correction of esotropia were discussed. Some methods of examining young children, and the findings to be expected, were reported in three broad chronological age groups. A short description of some common diagnoses and their related therapy was given, followed by illustrative case histories. In conclusion, the results in 140 cases of heterotropia treated before the patients were four years old were presented in table form, showing that 69 per cent of the cures were functional and 31 per cent cosmetic.

REFERENCE

1. Chavasse, F. Bernard: Worth's Squint, or The Binocular Reflexes and the Treatment of Strabismus, 1939.

AMERICAN ORTHOPTIC JOURNAL

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THE AMERICAN ORTHOPTIC JOURNAL'S TENTH BIRTHDAY

This issue of the AMERICAN ORTHOPTIC JOURNAL marks ten years of publication, an event which should not be allowed to pass unnoticed. Through the pages of the JOURNAL, orthoptic technicians and ophthalmologists alike keep pace with scientific progress in problems relating to neuromuscular anomalies of the eyes. The JOURNAL also provides it readers with a directory of the membership of the American Association of Orthoptic Technicians and notes regarding events of orthoptic interest. It is widely read by orthoptic technicians and others interested in the field of ocular motility. On behalf of the American Orthoptic Council, we would like to extend our greetings and congratulations to those who have made this JOURNAL successful. The first editor was Dr. Richard G. Scobee of St. Louis. Dr. Hermann M. Burian, Iowa City, assumed the editorship in 1953 and was followed by Dr. William E. Krewson, III, Philadelphia, in 1956, Dr. John W. Henderson, Ann Arbor, in 1958, and the present editor, Dr. Webb P. Chamberlain, Cleveland, in 1959. Each of these distinguished ophthalmologists has given untiringly of his time and knowledge in order that our excellent JOURNAL would be available to those who wish to receive it. The American Orthoptic Council and the American Association of Or-

thoptic Technicians are grateful to these men.

While we are mindful of the duties and obligations so unhesitatingly assumed by the editors, we know that no one of them would have been so willing to be "Captain" had it not been for the fact that each had a capable "crew." The associate editors —all members of the AAOT—have always worked in full cooperation with the editor and with each other. To Mrs. Dorothy Laughlin, Miss Mary Argue, Miss Nancy Capobianco, Miss Ann Eustis, Miss Joan Clavell, Mrs. Lorraine Lorenger, Mrs. Virginia Sorsby, Miss Dorothy Reimer, Miss Marjorie Snell, Miss Velma Ritter, Miss Mary Wackerhagen, and Miss Sally Moore, we also extend our thanks for earnest and successful endeavor. They have shown themselves to be a fine "crew," and it is hoped that those who follow will keep the ship on the course which has been charted.

The success of our JOURNAL, while due in large part to the work of the editors and associate editors, would not have been possible without the cooperation of the American Academy of Ophthalmology and Otolaryngology. The Academy has assisted greatly in the mechanics of publication, and its Executive Secretary-Treasurer, Dr. William L. Benedict, has encouraged us, supported us, and helped us. The Academy has played an essential role in making possible the publication of this JOURNAL. For all that has been done in our behalf, we wish to express our sincere appreciation.

We now hope that the second decade may bring a concerted effort to develop and maintain a journal of the highest standards.

EDMOND L. COOPER, M.D.

ORTHOPTICS: THE LAST DECADE AND THE NEXT

From the point of view of orthoptics, the past decade in review might be termed "the growing fifties."

The year 1951 saw the inception of the AMERICAN ORTHOPTIC JOURNAL with three articles and 55 pages. The 1959 JOURNAL has seven times the number of articles and 149 pages. We are proud of this growth and grateful to the American Academy of Ophthalmology and Otolaryngology for making it possible. Articles in the JOURNAL have shown the increasing emphasis on the physiology of exotropia, modifying the approach to its treatment. Misconceptions about fixation disparity have been clarified. Investigation has been made into all aspects of amblyopia ex anopsia. The last joint symposium of the American Orthoptic Council and the AAOT on the subject of pleoptics attracted an overflow audience.

The Lancaster award was established in 1952. A medal has been presented, once a year or less often, to some orthoptist who had made an outstanding contribution to orthoptics. The seven worthy recipients have been Julia Lancaster, Elizabeth Stark, Elizabeth Jackson, Frances Walraven, Louisa Wells Kramer, Elsie Laughlin, and Dorothy Bair.

In the field of education, the requirements for training have been raised. Two years of college and a

full year of practical training in orthoptics are now prerequisites, and the minimum age has been set at twenty years. The southern region of the AAOT has established a Jean Robinson Memorial Library which will lend orthoptic literature to students and anyone else interested. Gifts of books and reprints are being received.

The exhibits of the AAOT at the Academy meetings have continued to attract many visitors. Ophthalmologists have shown great interest in the materials displayed. Dr. Kenneth Roper has been unfailingly helpful and generous in allowing us space. The first presentation of orthoptics in the form of an exhibit to pediatricians took place in 1954, emphasizing early investigation and treatment. We now have several exhibits as a nucleus for a permanent exhibit library for use at pediatric and general medical meetings.

What of the sixties, on the threshold of which we stand? Orthoptics is a young science. It has survived the growing pains of youth, has been overpraised and unfairly condemned. It has been subjected to exploitation by charlatans. Most of all it has been nourished by farsighted ophthalmologists and guided into paths of science, that is, education, ethics, measurement and research.

I have never regretted my own choice of orthoptics as a career. After graduating in economics and political science, I was for a moment intrigued with thoughts of working in the United Nations, or in government circles in some distant land. The chance to train in orthoptics was suddenly offered, and after only a few weeks I was already convinced of its possibilities for action and research and felt the satisfaction of contributing in one vital area in the attainment of binocular vision.

FRANCES FOWLER,
President, A.A.O.T.

THE BASIC ORTHOPTIC COURSE

The American Orthoptic Council will again sponsor the Basic Course for Technicians this summer at Ann Arbor, Michigan, under the able direction of Dr. John W. Henderson. This course features an outstanding faculty. The period of instruction will occupy the eight-week summer session of the University of Michigan from June 20 to August 13, 1960, and is an official summer course of the University. Although not mandatory this year, it has been suggested that a minimum of three months practical training in orthoptics is highly desirable before enrollment in this course. Beginning with the summer session of 1961, this preliminary experience will become a specific requirement. It is hoped that this initial practical training will facilitate the students' understanding of the material presented in the basic course.

It is not necessary that the practical training taken after the basic course be completed in the same office or clinic in which the initial experience was gained. In fact, the Council feels that training in two different centers may be preferable.

There are a number of good orthoptic schools providing the full year of didactic training in one institution, and students from these schools are not required to take the Basic Course

offered by the Council. General information relating to the various opportunities for orthoptic training is available in the brochure "A Profession in Orthoptics" which can be obtained from the Secretary of the American Orthoptic Council, Edmond L. Cooper, M.D., 414 David Whitney Building, Detroit 26, Michigan.

For further details concerning the Basic Summer Course sponsored by the American Orthoptic Council, please contact John W. Henderson, M.D., Room 6155, Outpatient Building, University Medical Center, Ann Arbor, Michigan.

EXAMINATION FOR ORTHOPTIC TECHNICIANS

The annual examination of orthoptic technicians by the American Orthoptic Council will be conducted in August and October 1960.

The written examination will be nonassembled and will take place on Thursday, August 18, in certain assigned cities. It will be proctored by designated ophthalmologists.

The oral and practical examinations will be on Saturday, October 8, in Chicago just preceding the meeting of the American Academy of Ophthalmology and Otolaryngology.

Applications for examination will be received by the office of the Chairman of Examinations, Dr. Frank D. Costenbader, 1605 22nd St. N. W., Washington 8, D. C. Each application must be accompanied by the examination fee of $30.00. Applications will not be accepted after July 1, 1960.

DEVELOPMENT OF ORTHOPTICS

Recently, the Orthoptic Division in the Department of Ophthalmology of the College of Medicine of the State University of Iowa celebrated the twenty-fifth anniversary of its foundation. It was one of the first orthoptic departments established in this country. This occasion prompted me to think about the fact that orthoptics has now been actively pursued in this country well over a quarter of a century.

We tend to lose track of the development of the various branches within our specialty. Much valuable and interesting material is thus lost to the profession at large and to future generations. It seems to me that this would be an opportune time to put together a historical outline of the development of the various orthoptic departments in this country. Such an outline might contain a list of the ophthalmologists and orthoptists in charge of these departments throughout the period under consideration; it might also indicate the scope of its activities, clinical, investigative, and educational, as well as an indication of the development of the general trend of thinking and handling of orthoptic cases peculiar to each particular department.

The writer of this editorial will be glad to receive such outlines from any and all orthoptic departments for the purpose of collecting them and preparing them for publication in the AMERICAN ORTHOPTIC JOURNAL.

HERMANN M. BURIAN, M.D.

AMERICAN ORTHOPTIC COUNCIL—1960

The American Orthoptic Council is composed of three representatives each from the American Ophthalmological Society, the Section on Ophthalmology of the American Medical Association, the American Academy of Ophthalmology and Otolaryngology, and the American College of Surgeons. Three members are elected from the American Association of Orthoptic Technicians. The President of the American Association of Orthoptic Technicians also sits on the Council as an ex-officio member.

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ABSTRACTS OF OPHTHALMIC LITERATURE

Blankenstein, Samuel S.: *Diagnosis of eye defects that interfere with reading*, Sight-Sav. Rev., 28:207 (Winter) 1958.

There is little evidence of a major relationship between vision and reading disabilities. Refractive errors should be properly corrected. Therapy, in the form of glasses or orthoptics, should be limited to cases with symptoms directly related to the conditions being corrected.

Braun-Vallon, S., and Hollier-Larousse, H.: *Apropos the re-education of strabismic amblyopia by the Cüppers method*, Ann. d'ocul., 192: 121 (Feb.) 1959.

The numerous difficulties at every stage of pleoptic treatment are enumerated and described. The authors advise that extreme prudence be exercised in prescribing it. Therapeutic procedures are discussed.

Chamberlain, Webb P., Jr.: *Strabismus: review of the literature*, A. M. A. Arch. Ophth., 62:137-150 (July) 1959.

A comprehensive review of the 1958 literature on strabismus is presented with listing of references.

Diskan, Samuel M.: *An instant eye muscle balance screening test*, Tr. Am. Acad. Ophth. & Otol., 63:311-312 (May-June) 1959.

The purpose of the Atlantic City eye test is to detect vertical and horizontal ocular deviations simultaneously and instantly. Based on dissociation of the visual functions of the two eyes by colored lights, the test materials consist of red and green spectacles and an internally illuminated, light-proof box, the face of which is cut out to contain an illuminated red dot in an illuminated green rectangle. The testing distance is 20 feet.

The red dot is so situated in the green rectangle that a six-centimeter displacement up or down puts the dot outside the green rectangle—six centimeters representing the effects of one prism diopter at twenty feet. Similarly, the test will place the dot outside the rectangle if there are more than four prism diopters of exophoria or six prism diopters of esophoria. If the patient sees the dot within the rectangle, the phoria is within the limits specified. The author found the phoria standards selected practical for screening purposes.

Donnelly, William L.: *A review of double hyperphoria*, Eye Digest, 11:18 (Jan.) 1958.

The cause of double hyperphoria is not definitely known. In some cases it seems to be related to a weakness of a pair of elevators or depressors. In patients in whom measurements in the cardinal fields confirm the existence of paresis, the association of cause and effect is evident. The author outlines methods of examination, with particular attention to the cardinal fields, and the surgical procedures which may be indicated. He also discusses the muscles involved in the so-called A and V syndromes and possible surgical correction.

Dunlap, Edward A.: *Complications in strabismus and their avoidance*, Survey Ophth., 4:691-705 (Dec.) 1959.

Complications in strabismus usually fall into one of three groups: (a) incorrect or incomplete diagnosis, (b) improper surgical technique or wrong choice of muscles for

treatment, (c) surgical overcorrection or undercorrection. DFP and similar agents are mentioned as diagnostic aids. Surgical procedures and complications are discussed.

Goldberg, Herman K.: *The ophthalmologist looks at the reading problem*, Am. J. Ophth., 47:67-74 (Jan.) 1959.

The author differentiates the slow reader who reads below grade level because of his lower I.Q. from the retarded reader with a normal or high I.Q. Retarded readers can be divided into two major groups. Those whose defect is basically functional (primary retardation) and those who have normal intelligence and no basic defects (secondary retardation).

There is a surprisingly high incidence of ambidexterity or lefthandedness, a persistence of a tendency to reverse letters and symbols, sometimes actual mirror writing.

Defective vision and muscle imbalance do not have any significant role in the etiology of a condition influenced by spatial confusion and poor visual memory. If visual acuity is reduced, the child will have difficulty in interpreting symbols. Muscle imbalance and strabismus do not affect the interpretation of symbols but the effort to overcome such a weakness and to see binocularly may cause fatigue and discourage reading. Convergence insufficiency and muscle anomalies have been found in a large percentage of cases. These defects may result in a slow reader but have little or nothing to do with the retarded reader.

The author suggests a program which would lessen the burden on the teacher dealing with average students, and form a separate subdivision in the departments of education for children with reading problems.

Jonkers, G. H.: *A comparison of methods of determining stereoscopic vision*, Ophthalmologica, 137:15-21 (Jan.) 1959.

Statistical analysis of the results obtained in comparative investigation of three different devices shows that the results are not correlated and do not depend on pupillary distance and heterophoria. The practical significance of this statistical conclusion is discussed.

Jonkers, G. H.: *What is to be expected of amblyopia-treatment?*, Ophthalmologica, 137:365-371, 1959.

Analysis of the results in treatment of amblyopia with strabismus convergence.

The author is of the opinion that treatment of amblyopia does not show favorable results where fixed eccentric fixation is present. He has observed that in all other cases the attempt to improve visual acuity is justified; that the visual acuity of the amblyopic patient with strabismus convergence rises as far as 10/10 in very few cases; and that refraction has little to do with the origin of the strabismus convergence.

Konstas, K. A.: *Beobachtungen über den konvergenzexzess [Convergence excess]*, Ophthalmologica, 137:22-35 (Jan.) 1959.

The author describes the clinical picture of convergence excess and puts emphasis on examination during close work. For treatment, psychotherapy is recommended as well as eye and body hygiene.

On the basis of seven cases, the author states his views on the clinical picture, pathogenesis, etiology, diagnosis and therapy of convergence disturbances.

Kraft, C., and Hoette, E.: *Should a squint be operated on before or after amblyopia has been treated?*, Klin. Monatsbl. Augenh., 133:260 (Feb.) 1958.

The authors favor surgical correction before orthoptics or pleoptic treatment for the following reasons: (1) the operation may change abnormal correspondence into normal correspondence; (2) the euthyscope can be used more easily when the axes are parallel; (3) preoperative binocular vision is not neces-

sarily followed by postoperative orthophoria; (4) eccentric fixation may be improved by the operation; and (5) parents are perhaps more willing for their children to undergo orthoptic treatment after the success of an operation. Forty-eight patients with eccentric fixation were given this treatment; central fixation resulted in thirty-three. The age of the patient made no difference; the treatment was successful in patients who were 16, 17 and 20 years old.

Maggi, Carlo: *Classification of amblyopia*, Brit. J. Ophth., 43:345-360 (June) 1959.

Thirty cases of amblyopia treated by the Cüppers' method are discussed. Emphasis is laid on the physiologic importance of the retinal correspondence observed with regard to diagnosis and prognosis, and the selected cases have been classified accordingly.

The author discusses in detail (a) the method of classification, (b) physiological bases of high-grade amblyopia, (c) development of binocular correspondence, (d) the amblyopic eye in eccentric fixation, (e) the practical use of the macular afterimage in the re-education of the visual reflexes, and (f) visual development with regard to prognosis.

Mayweg, S., and Massie, H. H.: *Abnormal retinal correspondence*, Brit. J. Ophth., 43:293-301 (May) 1959.

A series of 22 cases of abnormal retinal correspondence were treated by Cüppers' afterimage method, and in four cases normal retinal correspondence was established. Four phases of the treatment are discussed: (1) occlusion, (2) orthoptic exercises, (3) surgical correction, and (4) postoperative treatment.

The authors observed that patients suitable for this treatment must be chosen carefully. From the results, they concluded that in certain cases of convergent strabismus with abnormal retinal correspondence, normal retinal correspondence could be developed by this method.

Mayweg, S., and Massie, H. H.: *Amblyopia ex anopsia (suppression amblyopia)*, Brit. J. Ophth., 42:257-269 (May) 1958.

This is a report on the Cüppers' afterimage method of treatment of amblyopia. It was given to patients who had not responded to occlusion of the fixating eye. The period of occlusion may last from one to eight months. Eccentric fixation was present in thirty-eight of the fifty patients treated. Age at onset varied from birth to three years.

Patients with central fixation responded more quickly than those with eccentric fixation, and there was a more rapid response in those who were given daily treatment. The cases assessed as showing no improvement were mainly those in which there was a lack of cooperation on the part of the patient or parent in carrying out the treatment. Better and quicker results were obtained in patients who had not had previous occlusion of the dominant eye, even when fixation was sufficiently eccentric to be diagnosed by the cover test alone. Therefore, in any case of amblyopia, a diagnosis of the type of fixation present should be made before occlusion or any other form of treatment is carried out. If adequate treatment is given, eccentric fixation is not apt to return once central fixation has been established, nor will the visual acuity developed be likely to become grossly reduced later on. Follow-up of these cases will be needed to show whether these opinions are correct.

McLaughlin, Samuel C., Jr.: *The elicitation of fusion in strabismus patients who are aware of diplopia*, Am. J. Ophth., 48:148-152 (July) 1959.

The purpose of this paper is to present some evidence which bears on the question of the effectiveness of the alternation exercise in eliciting fusion. The author describes his method for fusion with which he treated 59 patients. He found that 13 per cent were able to fuse with the alternation exercises. The paper includes 3 case reports and a theoretic discussion of his method.

Parks, Marshall M.: *Abnormal accommodation convergence in squint*, A. M. A. Arch. Ophth., 59: 364-380 (March) 1958.

The author studied the accommodation and accommodative-convergence ratio (A:AC) in 1249 children with comitant esotropia or exotropia, from the age of three months to twelve years. He concluded that an abnormal

A:AC was responsible for more than 10 degrees difference between the distance and near measurements in half the children tested. Regardless of age, bifocals control the symptoms but do not correct the defect in esotropia. Isoflurophate (DFP) almost normalizes the A:AC when used in growing children, but its effectiveness ceases after it is discontinued. In older children there is a tendency for the eyes to remain corrected after DFP is discontinued. Surgical intervention, when justified, permanently improves the A:AC.

Phillips, Calbert I.: *Strabismus, anisometropia, and amblyopia*, Brit. J. Ophth., 43:449-460 (Aug.) 1959.

This article covers anisometropia and its relationship to strabismus and amblyopia. The discussion is divided into four parts: (1) anisometropia and strabismus; (2) anisometropic amblyopia (without strabismus); (3) peripheral fusion in anisometropic amblyopia; (4) optical correction in anisometropia. Some specific cases are given, and the importance of peripheral fusion is stressed.

Priestley, Bruno S.; Byron, Herve M., and Wesley, Alan C.: *Pleoptic methods in the management of amblyopia with eccentric fixation*, Am. J. Ophth., 62:491-502 (Oct.) 1959.

This is a review of pleoptic methods, including the theory and practice of Cüppers' method with a description of the instruments and their use. Criteria for selection of cases are discussed, including the bearing of age, intelligence, motivation, type of eccentric fixation, and presence of fusional vergences on the results of the treatment. Eight cases from the New York Eye and Ear Infirmary are presented along with percentage figures from the published results of Bangerter, Cüppers and Sevrin, Krajevitch, Massie and Mayweg.

Urist, Martin J.: *Primary and secondary deviations in comitant squint*, Am. J. Ophth., 48:647-656 (Nov.) 1959.

The purpose of this paper is to present and discuss some cases of primary and secondary deviations in comitant squint. This interesting phenomenon is not rare, yet it is not well known. Primary and secondary deviations are found in three types of cases: (a) those with amblyopia, due to unequal innervation of the intraocular muscles; (b) those with anisometropia, due to unequal accommodation because of refractive error; and (c) those in which there has been unilateral surgical intervention.

Verhoeff, F. H.: *Fixation disparity*, Am. J. Ophth., 48:339-340 (Sept.) 1959.

The author discusses fixation disparity as reported by Ogle and Jampolsky. Verhoeff believes the term *fixation disparity*, presumed to have been originated by Ogle, is ambiguous and dismisses the subject as being unimportant as no one has been able to prove its existence.

Wagner, P.: *Beitrag zur motorischen Orthoptik [Report on motor orthoptics]*, Ophthalmologica, 137:131-136 (No. 2) 1959.

Description of three methods of training eyes in normal binocularity: (a) pure sensory orthoptics, (b) sensomotor orthoptics, (c) pure motor orthoptics. The author lays greatest stress on motor orthoptics.

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